POWER PLANT ENGINEERING

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The New Buick Plant

LONG DISTANCE CONVEYOR AND WOOD REFUSE BURNING EQUIPMENT A NOVEL FEATURE OF THIS PLANT

REALIZING the necessity of keeping pace with the increased power requirements caused by the continual expansion which has so characterized the growth of the automobile industry, the officials of the Buick Motor Co., subsidiary of the General Motors Corporation, decided in 1919 to erect a new power plant at their factory in Flint, Michigan, which would not only meet the necessary power requirements, but which would also embody the best features that modern engineering practice could afford. Today this plant is in operation and in the finishing stages of completion. It is without doubt one of the finest and best equipped industrial power plants of its kind in the country.

With 40 large buildings covering an area of over 200 acres, the power requirements of the Buick plant are considerable and while the new power plant will supply all other forms of power no attempt is made to generate all the required electrical energy. All electric current needed in excess of the 8000 kw. for which generating capacity has been installed, will be purchased from outside sources. This permits of securing the advantages of central station service combined with the economy obtained by the use of exhaust steam from steam-driven compressors for heating purposes.

FIG. 1. INTERIOR VIEW OF THE ENGINE ROOM AT THE BUICK PLANT

Designed to meet the needs of the particular factory which it serves, this plant possesses a number of interesting features not usually encountered in power plant practice. The combination wood and coal fired

boilers, for instance, should be of considerable interest to engineers of plants which have available for burning a limited quantity of wood refuse, not sufficient, however, to warrant the installation of an entirely wood-burning boiler.

While the 8000 hp. rated boiler capacity installed at the present time will satisfy power requirements for some time to come, provision has been made whereby the boiler room may be lengthened so that additional units may be added when needed. Present coal-handling equipment has also been installed with a view towards future expansion.

Coal-Handling Equipment

The coal-handling system furnished by the C. W. Hunt Engineering Corporation is simple and effective in operation and is of particular interest. Coal is delivered directly from bottom dump cars into a large track hopper. This hopper, as may be seen by reference to Fig. 2, is approximately 130 ft. from the power plant and is sufficiently large to accommodate two railroad cars side by side. From the bottom of the track hopper the coal is passed through a reciprocating feeder to a motor-driven coal cracker. This cracker consists of two cylindrical rolls made to revolve towards each other by means of spur gears keyed on the roll axles. The rolls turn in fixed centers and are of different pitch diameters in order to obtain an advance of peripheral speed of one over the other and facilitate better feeding of the coal, causing the lumps of coal to be dragged by the faster roll and slightly retarded by the slower. The rolls are heavy cast iron, faced and bored for steel axles, to which they are pressed, taper fitted, and keyed. Hardened steel, special form teeth are screwed up to a shoulder around the perimeter of the rolls and are renewable. The rolls are approximately 22 in. in diameter and are spaced 1¼ in. apart. This cracker, together with the feeder, is driven by a 40-hp. electric motor and has a normal capacity of 75 T. per hour.

The cracker discharges to an 18-in. belt conveyor passing through an inclined tunnel to a conveyor pit located adjacent to the power plant as shown in Fig. 2. This tunnel is 6 ft. in height, 9 ft. wide and inclines upward toward the power plant at an angle of 14 deg. 2 min., which is also the inclination of the belt conveyor. The lower end of this belt conveyor is located below the track hopper, 36 ft. below the ground level. The head end is equipped with a brush outfit and when running at a speed of 275 ft. per min. has a capacity of 75 T. per hr. It is driven by a 7½-hp. motor running at 1200 r.p.m.

The tunnel, which is constructed entirely of concrete, is sufficiently large to accommodate another belt conveyor of the type installed should future requirements demand.

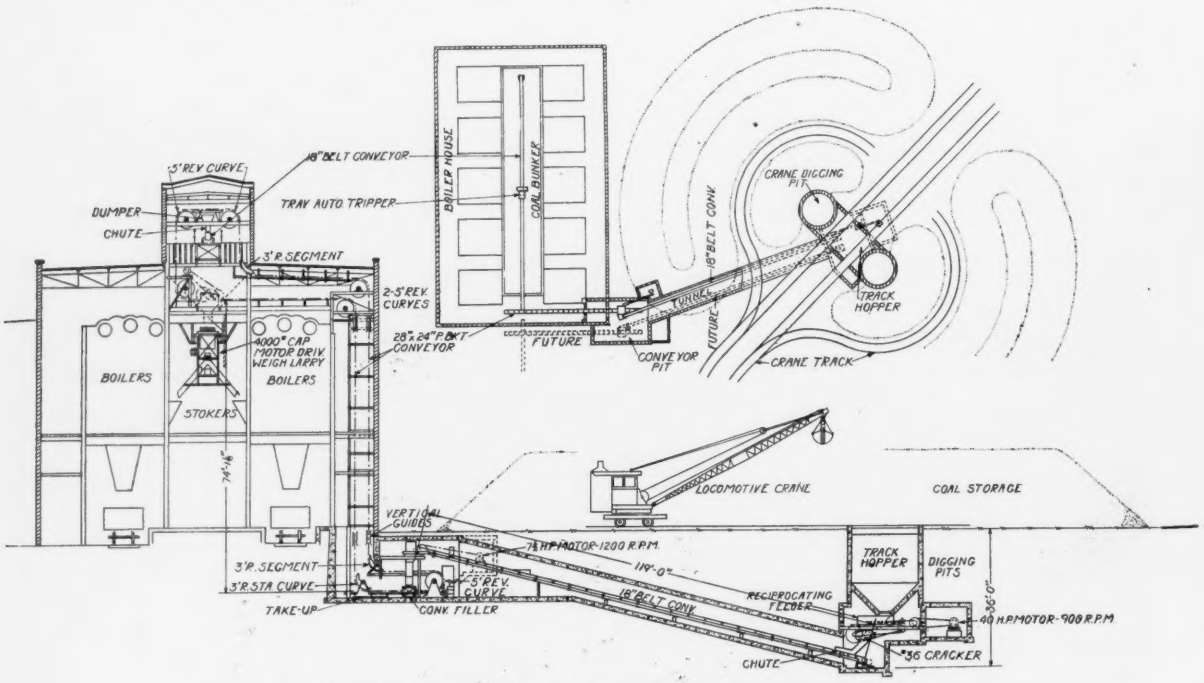


FIG. 2. PLAN AND ELEVATION OF COAL HANDLING EQUIPMENT

From the belt conveyor the coal is delivered through a filling mechanism to a 28 by 24-in. pivoted bucket conveyor which elevates it to the upper part of the power house as shown in Fig. 2.

This conveyor is of standard design fitted with sheet steel buckets and is driven by a 15-hp. motor. At a speed of 42 ft. per min., it has a capacity of 75 T. per hr., which conforms with the capacity of the associated equipment.

At the upper run of the pivoted bucket conveyor, a dumping cam engages cams on the sides of the buckets, causing them to tip and discharge the coal onto an 18-in. belt conveyor distributing to the boiler room bunkers. The latter runs at a speed of 300 ft. per min., is driven by a 5-hp. motor and is fitted with a traveling automatic tripper.

The conveyors have interlocking electric master control and individual control for all motors. This precludes the possibility of stopping one section of the sys-

tem while other sections remain running, thus jamming the system with coal at some point.

Coal is placed in storage and reclaimed by means of a locomotive crane. It will be noted by reference to the location plan that digging pits are provided adjacent to the track hoppers to enable the locomotive crane to place the coal in storage.

The Boiler Room

The boiler room is approximately 140 ft. long by 88 ft. wide and measuring from the ground level is 68 ft. high, exclusive of the coal-handling gallery which rises about 17 ft. above the roof of the boiler room. The building is of brick and steel construction with concrete floors. Large windows on three sides insure effective natural illumination in the basement and on the boiler room floor while skylights located directly above the boilers eliminate the necessity for artificial lighting during the daytime in the upper part of the boiler room.

As may be seen by referring to accompanying illustrations, the boilers are arranged in two rows with the firing aisle in the center. The coal bunkers are located directly over the firing aisle. The basement is occupied by the ash disposal equipment, the forced draft blowers and steam piping.

Present steam generating equipment consists of nine 823-hp. coal-burning, class M-30 Stirling boilers and two 329-hp. wood burning boilers of the same type, making an aggregate of over 8000 rated horsepower. While these boilers are not at the present time operated above rating, it is expected that they will be in the future. Steam is furnished not only to turbo-generators and air compressors but also the forge shop for operating a large battery of steam hammers. In addition large quantities of steam are required for heating for domestic and building heating purposes and for many pieces of auxiliary machinery installed throughout the plant. Steam is generated at a pressure of 150 lb. per sq. in.

The nine coal-burning boilers each have 8226 sq. ft. of heating surface and are equipped with Jones eight-retort, long underfeed stokers of the automatic cleaning type, controlled by Cole automatic regulators running normally at 525 r.p.m. The latter are belted to line shafting installed in front of the boilers and driven by either 5-hp. 440-v. a.c. G. E. motors or by reciprocating engines.

Coal is delivered to the stoker hoppers by a C. W. Hunt motor-driven weigh larry having a capacity of 4000 lb. The coal bunkers which are of concrete are fitted with 24-in. valves hand operated from the platform of the weigh larry.

FIG. 3. INTERIOR VIEW OF BOILER ROOM

Wood-Burning Equipment

The two 329-hp. wood-burning boilers are of the same general construction as the coal-burning boilers but are equipped with settings particularly suited for the use of wood as fuel. They are equipped with Allington and Curtis wood waste stokers which are supplied by a long distance shavings conveyor of the same make.

The furnaces which are shown in Fig. 4 are of the Dutch oven type, fitted with grates, ash pits and bridge walls similar to those used in ordinary hand-fired boilers. The furnace proper is located below the boiler room floor. The wood waste stoker has a large receiving mag-

azine which is kept about three-quarters full of material and takes up the variation in the volume of material as made by the wood-working machines and the hog. The magazine is of special design to prevent arching of material and is fitted at the bottom with a screw type of conveyor which delivers the material to a short chute, through which it drops by gravity into the top of the Dutch oven. Much of the finer material is burned in suspension while the coarser particles fall upon the grate bars. The screw conveyor and the fuel itself makes a seal which prevents air entering the fire box with the fuel.

The rate of feed can be adjusted by the fireman instantly but apparently requires no attention when once set to furnish the amount of fuel wanted for the air current is produced by a positive blower. This blower does not handle material but induces a current of air in the conveyor line into which the material is introduced by means of a charger. The charger receives the material by gravity and introduces it automatically into the discharge pipe from the blower against the pressure therein, and the air current carries the material to the end of the line, where the air and material are separated by a collector, which permits the material to drop by gravity, while the air escapes into the atmosphere.

The blower is driven at 250 r.p.m. by a motor and the charge is driven from a small pulley on the blower shaft, which runs the charger at 10 r.p.m. The pipe line is of special heavy construction with reinforced

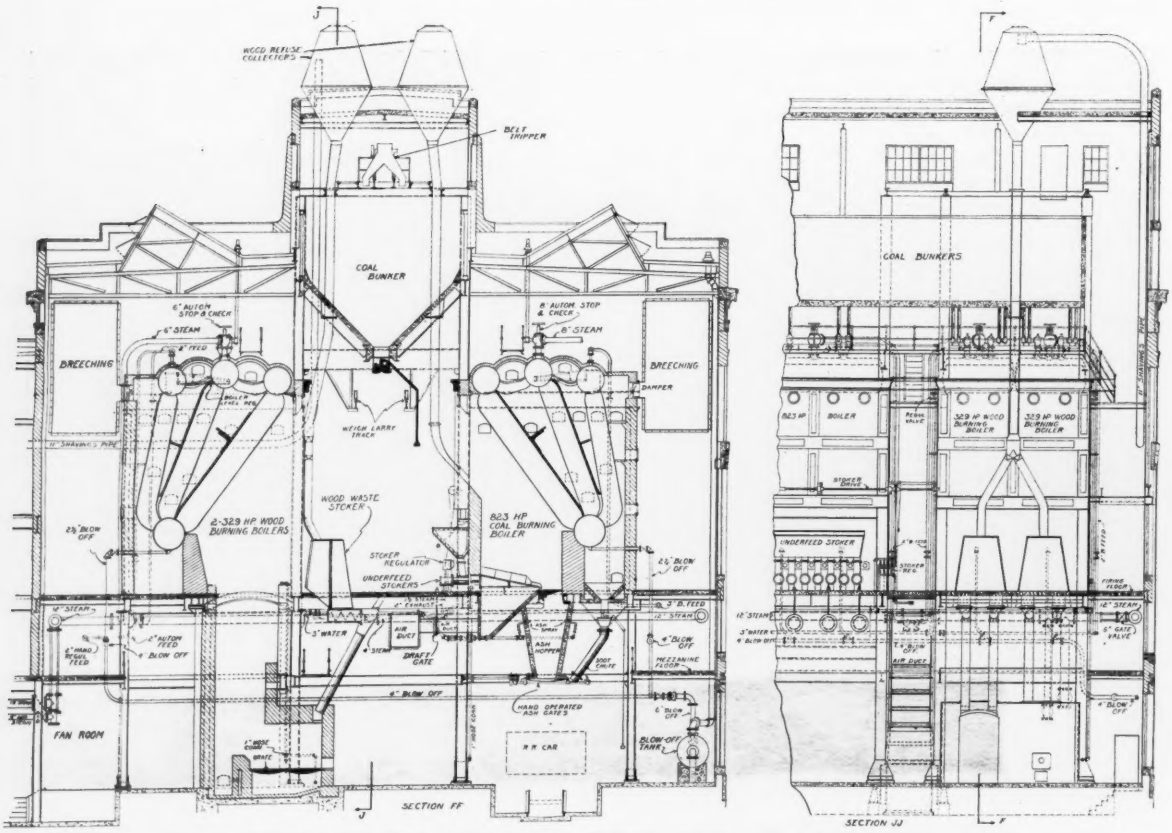


FIG. 4. SECTIONS THROUGH BOILER ROOM SHOWING DETAILS OF WOOD-BURNING BOILER

furnaces. The feed is therefore uniform and adjusted exactly to suit conditions in the wood-working plant. There is also the opportunity of accurately regulating the air supply, due to entire absence of cold air. The two important features mentioned above are claimed to result in a large saving of fuel.

Each furnace is provided with two downspouts. The grates are approximately 9 ft. long and are placed two feet above the floor. The combustion chambers are large, the height from the grate bars to the center of the mud drum being over 29 ft., while the overall furnace length above the grates is 13½ ft.

Wood refuse handled by the stokers is blown from the body factory, a distance of about 3600 ft. through a tunnel by means of a long distance conveyor system, the pipe line being 11 in. in diameter. A high velocity elbows and angles, of which there are a large number, due to the necessity of passing around buildings with the tunnel.

In addition to the usual shavings and sawdust, this same system handles all the blocks and edgings from the body factory, after they have been ground up by the hog. Two hogs, installed by Mitts & Merrill Co., are set side by side, and are designed to be used on alternate days so that the knives can be given proper care without overtime work. Either hog delivers the material to a fan which carries it up to a collector located above the charger.

It is estimated that all the wood refuse can under emergency be burned by one of the wood-burning furnaces. However, in addition to the above described wood-burning equipment, one of the coal-fired boilers is

fitted with an arrangement which allows wood refuse to be burned in combination with the coal fired on the underfeed stokers. This arrangement is extremely simple, consisting merely of a down spout introduced through the furnace front into the upper part of the combustion chamber as illustrated in Fig. 4. Shavings and dust from the collector on the roof is thus fed into the furnace on top of the burning coal bed.

Ashes from the stokers are dumped into the ash hoppers as shown in Fig. 4, where they accumulate until released by opening the ash gates. The latter are hand-operated through rack and pinions and sprocket wheels. The ash hoppers, as may be seen, are fitted with ash sprays for cooling the ash and settling dust. The back of the furnaces, that is, the space at the rear of the bridge wall, is fitted with an arrangement for the removal of soot and dust which tends to accumulate there. This arrangement, as shown in Fig. 4, consists of a sheet metal spout which allows the soot to discharge into the railroad cars below, together with the ashes. A hand-operated valve controls the discharge.

Forced Draft

Forced draft is supplied to the boilers by three Buffalo Forge Co. double turbo Conoidal fans, each of which is capable of delivering 100,000 cu. ft. of air per min. One of these fans is driven by a 225-hp., 440-v.

FIG. 5. ABOVE THE COAL BUNKERS. SHOWING BELT CONVEYOR WITH TRAVELING TRIPPER

Allis-Chalmers induction motor, one by a Westinghouse steam turbine, while the third is equipped with a dual motor and turbine drive, i.e., a turbine is direct connected to the shaft on one side of the blower while a motor drives the other two. These are installed in the blower room under the mezzanine floor.

The blowers deliver air to the main air duct of sheet metal 3 ft. 6 in. wide by 4 ft. high installed on the basement ceiling in the center of the room as shown in Fig. 4, from which feeders are taken off to the boiler furnaces. The air to the individual furnaces is controlled by means of 20-in. blast gates, installed in the feeder ducts, which are hand operated from the boiler room floor.

Furnace gas is conducted through two lines of tapering sheet metal breechings running behind the boilers to two Custodis perforated radial brick chimneys 225 ft. high. Boiler dampers are automatically controlled by steam pressure.

Steam is taken from the boilers through 8-in. feeders connecting into a 12-in. main boiler room header. An 8-in. Schutte automatic stop and check valve is interposed between the steam drum and the feeders. Each boiler is equipped with two sets of twin safety valves exhausting through the roof through 4-in. lines.

Each boiler has two 2½-in. blowoff lines emerging from the rear walls and connecting into a 4-in. blowoff main on the mezzanine floor on each side of the boiler room. At the north end of the boiler room basement the two 4-in. blowoff lines connect into a 6-in. line which discharges into a 48-in. blowoff tank as shown in Fig. 4.

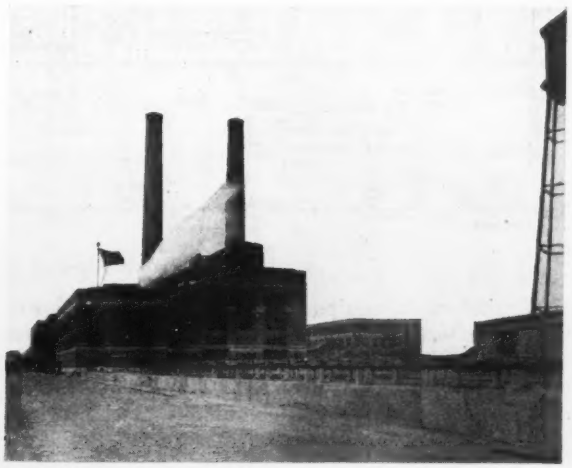


FIG. 6. EXTERIOR VIEW OF THE NEW BUICK PLANT WITH SPRAY POND IN THE FOREGROUND

Boiler feed water is supplied to the boiler room through 10-in. feed-water headers and is distributed to the boilers through 3-in. feed lines as indicated. Three boiler feed pumps are provided. These are Alberger 4-in., 3-stage turbine pumps, each having a capacity of 450 gal. per min. at a speed of 2560 r.p.m. when operating against a 512-ft. head. They are direct connected to Alberger steam turbines equipped with Fisher governors. One of these pumps is capable of carrying five boilers.

Copes automatic feed water regulators maintain constant water level in the boilers and "three in one" Precision draft gages register the pressure in the flue connection, the combustion chamber and the ash pit respectively. Republic indicating steam flow meters furnish information in regard to the load carried by each boiler. Diamond automatic soot blowers installed on all boilers prevent the accumulation of soot and dust on the boiler tubes.

The Engine Room

The engine room conforming with the boiler room is of brick and steel construction 178 ft. long by about 53 ft. wide. The interior is faced with a glazed cream-colored brick to within 6 ft. of the floor from which point down a dark brown glazed brick is used. This makes a very effective wainscoting. This floor is of

square red tile spaced ½ in. apart with cement filling and laid diagonally. An abundance of natural illumination is furnished through large widows and skylights. At night illumination is secured by large incandescent lighting units suspended from the ceiling between the steel roof trusses.

The six air compressors are Worthington heavy duty, cross compound Corliss, two-stage units equipped with feather valves. Two of the machines have 18 and 36-in. steam cylinders, 32 and 19-in. air cylinders by 30-in. stroke, are designed to operate at 110 r.p.m. and give a piston displacement of 3050 cu. ft. per min. These

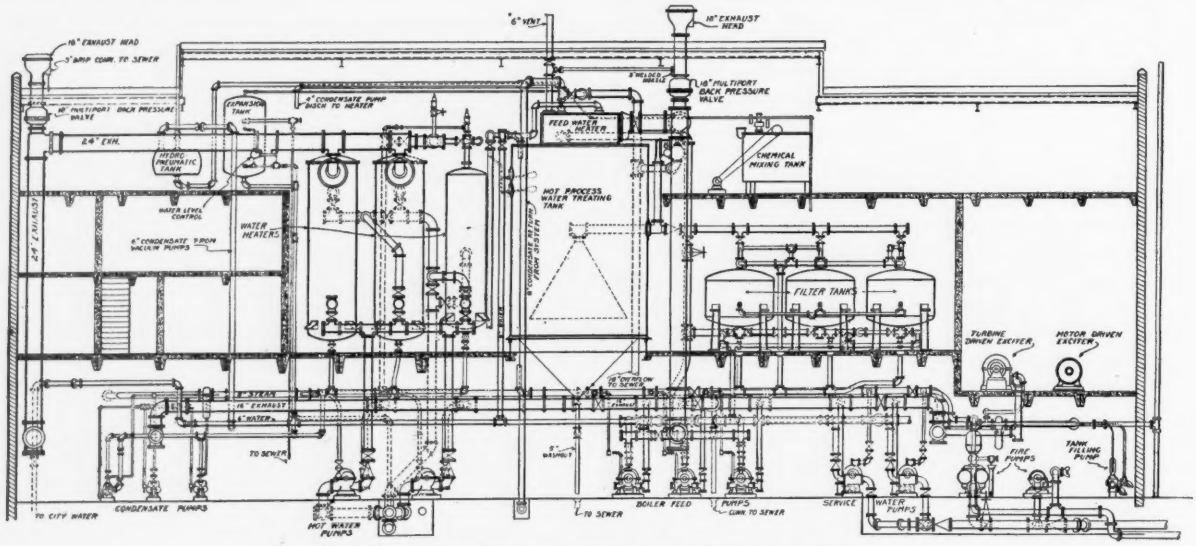


FIG. 7. LONGITUDINAL SECTION THROUGH PUMP ROOM

Engine room equipment consists of six air compressor units, two turbo-generating units with separate exciters, a 25-panel switchboard, two motor generator sets and the battery room. A 20-T. Whiting traveling crane is provided for the handling of machinery.

were installed in the old power plant in the spring of 1915. Upon completion of foundry extensions the following year a third machine was added of slightly different dimensions, due to slight change in operating conditions. The steam cylinders were 19 and 36 in.

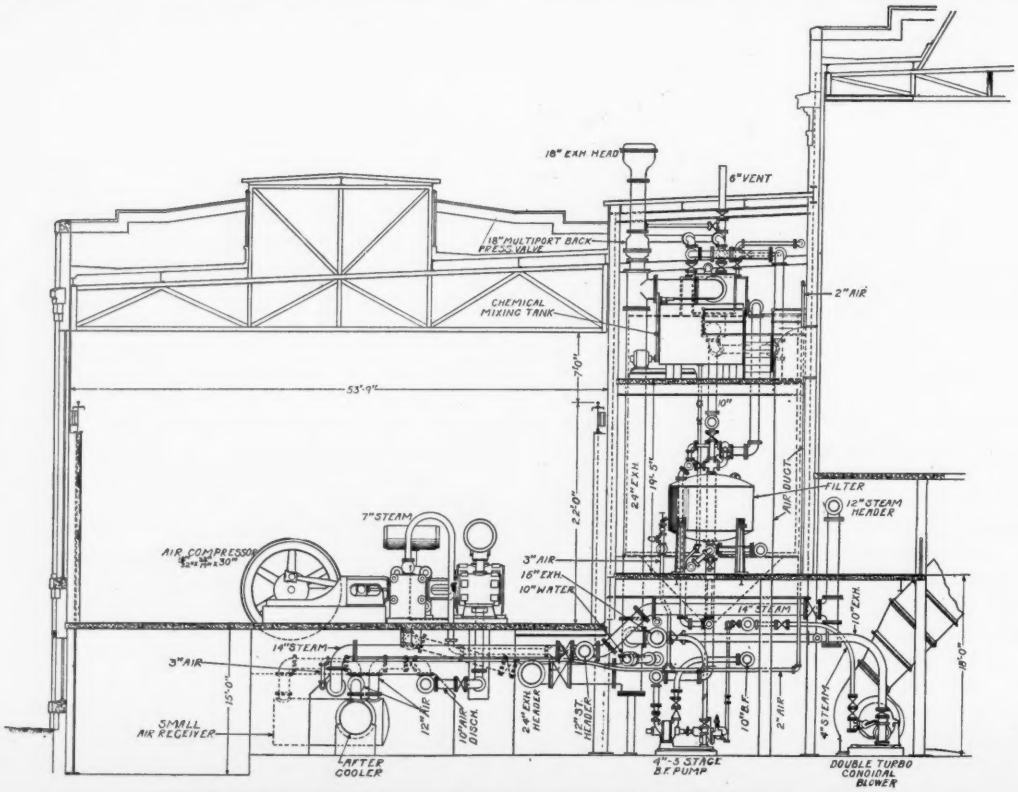


FIG. 8. TRANSVERSE SECTION THROUGH PUMP ROOM AND ENGINE ROOM

and the air cylinders were 32 and 20 in. and the stroke 30 in., also operating at 110 r.p.m. and giving a piston displacement of 3050 cu. ft. This machine was installed at the beginning of the year 1917.

When the new power plant was designed it was decided to move these compressors to the new plant and increase the capacity by the purchase of three additional machines of 3500 cu. ft. each, making a combined compressed air plant of 19,650 cu. ft. piston displacement. Machines were chosen having 18- and 32-in. steam cylinders, 32- and 19-in. air cylinders by 30-in. stroke designed to operate at 125 r.p.m. and at this speed having a piston displacement of 3475 cu. ft. each. The new plant thus consists of three old machines and three new ones. The frames of these machines are of the heavy duty rolling mill type, massive in construction with full length support on the foundation. The valve cranks on the Corliss gear are operated by direct drive, thereby eliminating the use of rocker plates. Releasing gear is of the semi-gravity latch type, capable of operating at high speeds. Air cylinders are of semi-steel. Both the cylinder and heads are provided with large water jackets. The intake air is completely separated from the heating surfaces by a water jacket, assuring the coldest possible air supply. The feather valves are simple and light in construction, are quiet in operation and offer little resistance to the air passing through them.

Each compressor is equipped with an intercooler supported crosswise between the high and low-pressure cylinders about 9 ft. above the floor. The high-pressure cylinders of all compressors discharge air at 100 lb. pressure into a common 12-in. air line from which it is delivered into three air receivers, two of which are 5 ft. 6 in. in diameter by 18 ft. long while the third is 4 ft. 6 in. in diameter by 11 ft. 2 in. long. Two Ingersoll-Rand after-coolers, each having a capacity of 2000 cu. ft., cool the air on its way to the factory.

Steam is delivered to the compressors at from 135 to 150 lb. pressure through 7-in. headers; the exhaust is through 14-in. lines into a 24-in. common exhaust main. These details are clearly shown on the cross section, Fig. 8.

The turbo-generators are General Electric, single cylinder units, generating 3 phase, 60 cycle current at 5000 v. with capacities of 3000 and 500 kw. respectively. Both machines exhaust into Worthington jet condensers equipped with motor-driven centrifugal pumps.

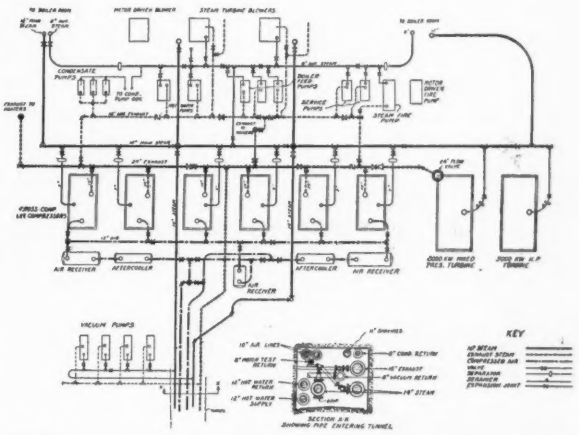


FIG. 9. SCHEMATIC VIEW SHOWING IMPORTANT ENGINE AND AND PUMP ROOM PIPING. ALSO A CROSS SECTION OF PIPE TUNNEL

The 5000-kw. unit is a straight high-pressure machine, but the 3000-kw. unit is a mixed-pressure type turbine using both high and low-pressure steam at the same time. The low-pressure steam is obtained from the exhausts of the six air compressors previously described, together with the exhaust from a large number of steam hammers in the forge shop. This exhaust steam is introduced into the low-pressure stages of the turbine through a 28-in. Cochrane receiver separator and a 24-in. flow valve of the same make which prevents any possibility of high pressure steam feeding through the turbine into the low-pressure main, should the latter supply fail.

High-pressure steam to both turbines passes through Crane separators and General Electric strainers, thus insuring against blade stripping caused by water or foreign matter entering the machines. Twenty and 24-in.

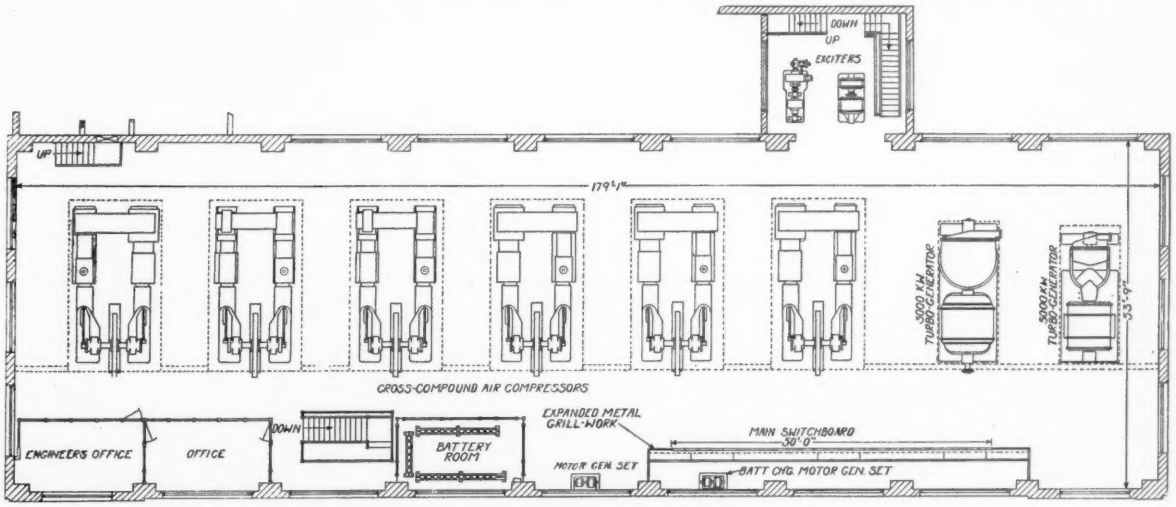


FIG. 10. PLAN OF ENGINE ROOM SHOWING LOCATION OF APPARATUS

Cochrane Multiport back pressure valves are fitted into the atmospheric vent lines from the condensers of the mixed and high-pressure turbines respectively.

Condensing Water

The Buick plant, unfortunately, is not conveniently located with reference to a river or other body of water

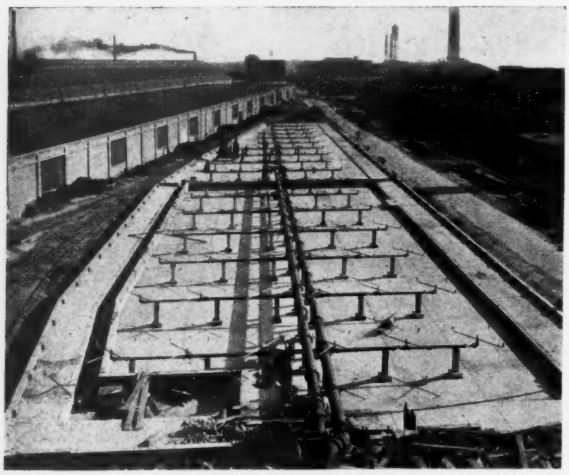


FIG. 11. PHOTOGRAPH OF SPRAY POND SHORTLY AFTER COMPLETION

and it became necessary therefore to provide a means of cooling the condensing water. After considering various possibilities, a spray cooling pond was finally decided upon, there being sufficient ground area available to permit of its construction. This pond, which is equipped with a Spray Engineering Co. cooling system and located only a few feet from the power plant, is of concrete, irregular in shape, 445 ft. in length by an average of about 90 ft. in width.

A novel feature of this pond is that it is built in two sections, each section of which may be used independently. This feature is well illustrated in the photograph, Fig. 11, and details of construction may be seen in Fig. 12. Reference to the latter will show that the floor of the rear section is 1½ ft. higher than the floor of the forward section. Water from the rear section flows by gravity through a trough alongside of the forward section to an intake tunnel 5 ft. wide by 7 ft. 3 in. high leading to the power plant. This tunnel serves as the intake from both sections of the pond.

The pond is equipped with two independent systems of center jet spray nozzles, arranged in units of five nozzles each, one system for each section of the pond. There are 220 nozzles for each section, making a total of 440 for the entire pond. The pond will cool 16,800 gal. per min. 16 deg. F. based on a ratio of circulating water to steam of 60 to 1.

The Pump Room

The pump room, located between the boiler and engine room, contains most of the auxiliaries together with the water softening and heating equipment. A longitudinal section of this room is shown in Fig. 7, reference to which will serve to indicate the location of the apparatus and the associated piping. The basement, as will be noted, is mostly occupied by pumps, while the first floor contains the water-treating tanks.

Water-Treating System

The Sorge-Cochrane hot process water softener shown in the center of the room, Fig. 7, has a capacity to soften and heat 32,000 gal. of raw water per hr. and to heat in addition 28,000 gal. per hr. of condensate or returns. The water supplies are delivered over separate stacks of trays in the heating chamber which is on top of the mixing tank. The chemical proportioner is located on the second floor of the pump room and is entirely automatic in operation. The amount of chemical reagent fed is proportional to the quantity of water flowing through the system.

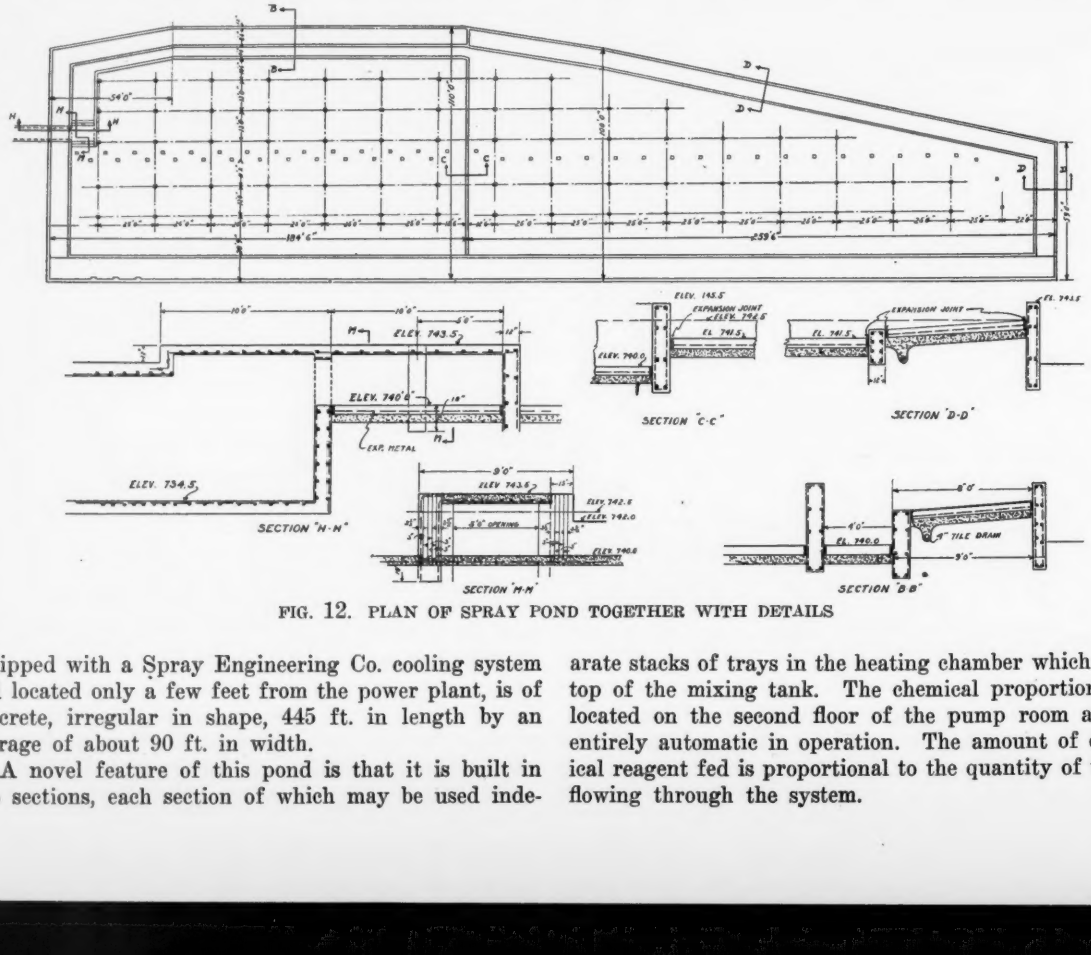


FIG. 12. PLAN OF SPRAY POND TOGETHER WITH DETAILS

The water supply at this plant comes from the Flint River through the city mains and is received at a pressure of about 30 lb. at the regulating valve. A sample of this water, upon which the softener guarantees were based, was clear and gave the following analysis:

Calcium Carbonate	6.30	grains per U.S. gal.
Calcium Sulphate	4.61	" " " "
Silica	0.37	" " " "
Iron Oxide and Alumina	0.33	" " " "
Sodium and Potassium Sulphate	0.82	" " " "
Sodium and Potassium Chloride	1.08	" " " "
Volatile and organic	1.20	" " " "
Total solids by evaporation	19.54	" " " "

For softening in the system installed, this water requires about 0.73 lb. of soda ash per thousand gal. and about 2.07 lb. of lime.

Exhaust steam from the compressors and hammer shop under a back pressure of about 3 lb. per sq. in. gage, at which pressure it is also supplied to the heating system, is used to heat the water in the softener. In case the supply of exhaust steam is not sufficient, live steam is received through a Fisher reducing valve. From the softener the water passes to the boiler feed pumps for delivery into the boilers. The normal feed water temperature is from 210 to 212 deg.

Raw water to the softener is first passed through filter tanks, three of which are provided. These, as shown in Figs. 7 and 8, are located adjacent to the treating tank and are 8½ ft. in diameter by 7 ft. in height. All water is measured by a 3-in. Venturi meter furnished by the Builders Iron Foundry.

Hot water for heating and factory purposes is heated in three Wickes Boiler Co. closed type heaters, two of which are low-pressure heaters supplied with exhaust steam at 3 lb. pressure, while the third is a high-pressure unit heated by live steam. The two low-pressure units each have a heating surface of 2540 sq. ft. and a capacity of 3000 gal. per min. at temperatures of from 140 to 180 deg. The high-pressure heater has a capacity of 2000 gal. per min. at a temperature of 180 deg.

Water is circulated through heaters and the heating system by two Worthington centrifugal pumps driven by 185-hp. Moore steam turbines.

Three duplex direct-acting pumps, designated condensate pumps in Fig. 7, return condensate from various parts of the plant. Two of these 7 by 4½ by 10-in. Prescott, while the third is a 6 by 5¾ by 6-in. Worthington. The speed of these pumps is automatically controlled by Kieley and Mueller condensation receivers and pump governors.

The heating system is a Warren Webster vacuum system and comprises a total of 420,000 sq. ft. of radiation installed throughout the plant. Four Union vacuum pumps for the heating system are installed in a vacuum pump room in a sub-basement underneath the transformer room in the basement. Three of these pumps are 10 by 12 by 16 in., while the other is an 8 by 10 by 12 in.

Fire protection is secured by means of two fire pumps, one an Allis-Chalmers two-stage centrifugal driven by a 100-hp., 440-v., 3-phase, 60-cycle induction motor and the other a Buffalo 18 by 10 by 12-in. duplex direct-acting steam pump. The former when running at 1750 r.p.m. is capable of delivering 1000 gal. per min. against a 231-ft. head.

Two De Laval turbine drivers centrifugal service pumps supply water to the factory for general service purposes. These have capacities of 2000 gal. per min. under 125-ft. head. Suction is taken direct from the city mains.

Electrical System

Although generating capacity totalling 8000 kw. has been installed, no attempt is made to generate all the current required in the shops. A considerable amount of power is purchased from outside sources.

Excitation for the two turbo generators is secured by two 75-kw., 125-v., 600-amp. Allis-Chalmers exciter sets; one driven by a 110-hp., 440-v., 3-phase 60-cycle motor while the other is turbine-driven. These, as may be seen by referring to the single line wiring diagram, Fig. 14, are connected to a common exciter bus. Field control on the generators is by motor operated rheostats remote-controlled from the main switchboard.

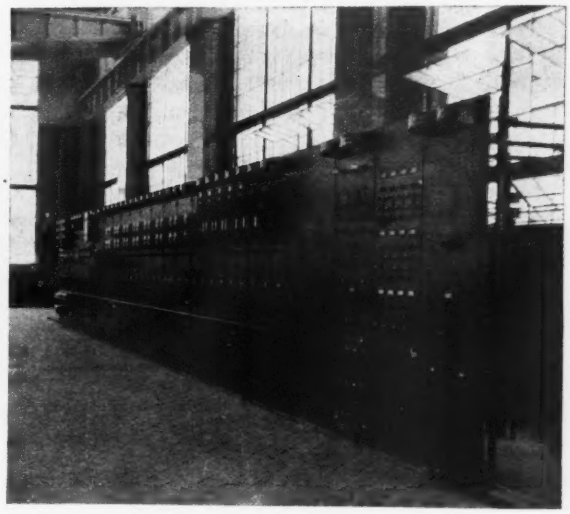


FIG. 13. MAIN SWITCHBOARD

Each generator is connected to its respective generator bus through Westinghouse oil switches which are automatic on reverse power only. A 3000-amp. bus disconnecting switch is provided for connecting the two busses.

Purchased power is delivered to the purchased power busses through oil circuit breakers and disconnecting switches as indicated. Three 3000-amp. disconnecting switches are provided for sectionalizing the purchased power bus.

The plant feeder may be supplied either from the station generator busses or from the purchased power bus by merely throwing the 2000-amp. double throw disconnecting switches one way or the other.

The high-tension station service bus is supplied by either of two feeders from the high tension switch room. For station lighting purposes, the voltage is reduced from 4600 to 115 v. by means of two 50-kv.a., 4600/230/115-v. transformers connected between high tension station service bus and the lighting bus. The station power bus is supplied with 440 v. current in a

similar manner through three 500-kv.a., 4600/460-v., power transformers.

All high-tension busses and circuit breakers are located in a switch room in the basement. The circuit breakers are controlled from the main switchboard, a photograph of which is shown in Fig. 13. Control circuits are supplied with direct current from a 55-cell storage battery, with six end cells, for which a 5-kw. Allis-Chalmers motor generator charging set is provided. The other 5-kw. motor generator set indicated in Fig. 14 is a Burke Electric Co. unit, used to supply the stoker motors on the wood-burning boilers.

All plant feeder circuit breakers are equipped with overload relays set for 0.75 sec. The purchased power feeders are automatic on reverse power, the relays being set for 0.3 sec.

Piping

In accordance with best modern practice, practically all piping is below the engine room floor. All piping was done by the Urbaner Atwood Heating Co. Chapman valves and fittings were used throughout the plant. Steam is supplied to the air compressors and the turbo generators through a 12-in. main steam header running the entire length of the basement. This header is supplied from the boiler room by four feeders; three of which are of 14-in. diameter while the other is a 12-in. line. Two of the 14-in. feeders connect into the main steam header by means of crosses and continue on into the tunnel to the shops. The air compressors are fed from the main header by 7-in. lines while the high and mixed pressure turbines are fed by 10 and 8-in. lines respectively. The main header is well provided with sectionalizing valves so that portions of the line may be cut off in case of accident without interrupting service on other parts of the system.

An 8-in. auxiliary steam line supplies the auxiliaries in the pump room and other apparatus in the vicinity. This is supplied from the boiler room at both ends of the building and is in addition cross-connected to the main steam header as indicated in Fig. 9.

The four steam-driven vacuum pumps used on the heating system and located below the transformer room in the sub-basement are supplied with steam from a 3-in. loop, each end of which is connected into one of the two 14-in. high-pressure steam headers running to the shops.

All compressors, as stated previously, exhaust into a common exhaust main running the length of the basement. This is a 24-in. line tapering to 28 in. at the end where it enters the low-pressure stages of the mixed pressure turbo-generator. The other end passes up through the building to the upper part of the pump room where it branches; one branch connecting into the two low-pressure hot water heaters while the other passes out through the room through an 18-in. Cochrane multiport, chain operated back pressure valve to an 18-in. Swartout exhaust head. Another exhaust riser coming up through the center of the building connects into the feed water heater and to the atmosphere in the same manner as the first one described.

The compressors exhaust into the main through 14-in. lines as shown. An 18-in. line from the tunnel supplies the exhaust steam from the hammer shops.

The auxiliaries exhaust into a 16-in. auxiliary exhaust main which connects into the main exhaust line at both ends as indicated in the schematic drawing.

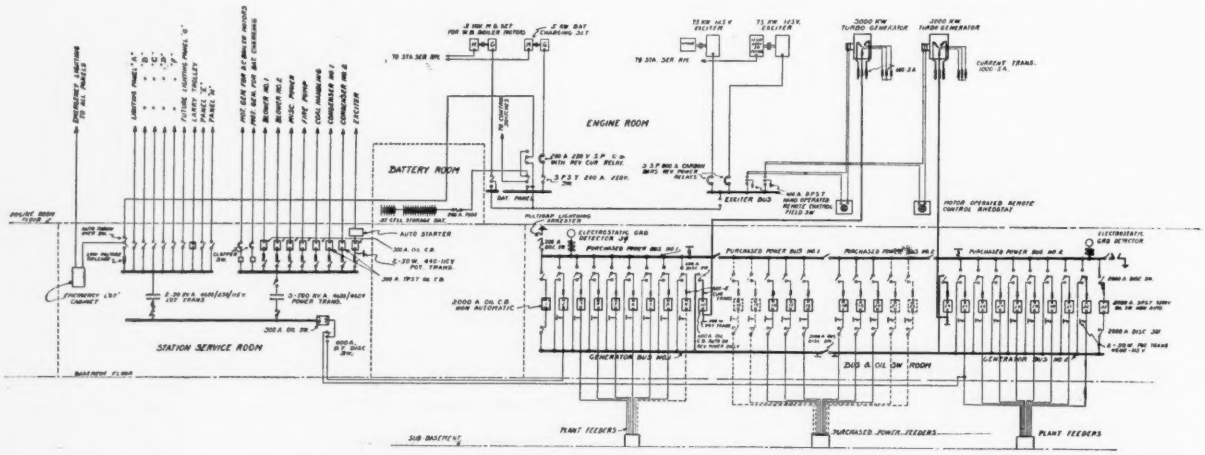


FIG. 14. SINGLE LINE DIAGRAM OF ELECTRICAL SYSTEM

Air intakes to the compressors are constructed of sheet metal, of rectangular cross section. There are three such intakes, one serving two compressors. Two of these measure 16 by 30 in., while the third measures 16 by 34 in. The intake ducts leading to the individual compressors are of similar construction, 18 by 12 in. in cross section.

Pipe Tunnel

All steam, air and water lines for distribution to factory buildings are installed in a concrete tunnel 10 ft. wide by 8 ft. high. This tunnel, a cross section of which is shown in Fig. 9, contains the following pipe lines: Two 10-in. compressed air lines; one 8-in. motor-test return line; two 14-in. high-pressure steam lines; one 12-in. hot water supply line; one 12-in. hot water return line; one 18-in. exhaust steam line; one 8-in. vacuum return line; one 8-in. condensate return line; one 11-in. shavings conveyor line.

Expansion joints are placed in these lines at suitable intervals with anchors midway between. Radiation

losses from the steam piping is reduced to a minimum by 85 per cent magnesia insulation.

Conclusion

The plant was designed jointly by the Du Pont Engineering Co. and the Buick Motor Co., while all construction work was done by the building department of the latter company. The plant is in charge of H. L. Weckler, works engineer of the Buick Motor Co., to whom credit is hereby extended for his valuable assistance and co-operation which has made possible the preparation of this article.

World's Power Field Receptive for American Equipment

Countries Developing Power Industries are Raising Capital Principally at Home. By L. W. Alwyn-Schmidt

DEVELOPMENT of power projects outside Europe, which had been temporarily suspended during the war, has now been taken up again and power engineers are busy in Asia, South America and Australia to complete projects planned before the war or having been taken up during the last two years. Although the financial situation of the world is still much disturbed, there is nevertheless apparently no lack of funds for power development. Most likely it is expected that power development outside Europe will to a certain extent relieve the economic pressure upon Europe, permitting the nations in question to work out their own salvation.

In the northern half of the American continent, power development is dominated, of course, entirely by United States influences. Conditions in Canada are much the same as those in our own country and the frequent exchange of ideas between the United States and Canada leads naturally to a co-ordination of effort which makes the two industries more or less interdependent. As the result, we have gained the habit of looking upon Canadian ground practically as upon our own power field and let it go at that. Newfoundland is to have a new light and power company incorporated with $1,500,000. This will give additional electrical power to St. Johns which will be used for a general improvement in the light and power service with some power left over for the street car service.

In South America, power development has also now reached the state of systematic organization. The continent has had a severe lesson as to its economic weakness caused from lack of coal and other power sources and it seems that South American economists have awakened to the fact that only far-reaching measures will provide security. These are to be found by replacing coal as much as can be by electrical power gained from water power sources and by reducing the present waste in power production by the use of large central stations similar to these in use in Europe. A good example for the growing of this tendency is the steady increase in the electrification of South American railroads as evidenced, for instance, in the case of Brazil where the electrical railroad equipment is increasing steadily.

South America Finances With Own Capital

South America, having found difficulty in securing capital in Europe during the war, has now learned to finance many of its industrial enterprises by domestic capital, which is also of bearing upon the growth of the electrical power industry. This has no longer to wait upon the convenience of European capitalists. Instead it relies to a greater extent upon the domestic investor with American capital taking an increased interest in South American undertakings. Unfortunately there is evidence that our banks have not shown a full understanding of the many problems of South American financing during the war, with the result that there is much grumbling; possibly a change will take place now when capital becomes easier again in the United States. From Paraguay is reported a plan to build an electrical power plant on the upper Parana River at Encarnacion. The city is an important point in Paraguay, as it is the end of the Paraguayan railroad system connecting with the Argentine railroads across the river. The contract for this undertaking will go abroad and it is said that there is much interest for the project in European electrical circles. The outlook for the plant should be very good, as it will be placed in a rich and promising district.

Bids had been called early this year for a power and lighting plant in San Francisco de Macoris in Santo Domingo. Attention is drawn in this respect to the steadily increasing operation expenses of practically all smaller power plants in South and Central America. The high cost of living has reached these parts of the world as readily as it has passed over Europe and North America, with the result that operation expenses of public utilities have increased to such an extent as to make necessary considerable increases in the income of the companies. Trouble, for instance, had arisen in Puerto Plata in the Dominican Republic over the rates charged by the station serving this city and Santiago. This plant also furnishes the power for the water supply of the latter city which has to be pumped up from the Yaque River. The plant is an American enterprise and the American company has had difficulties to continue operation at the existing rate of 20 cents per kilowatt-hour. It is of course entirely out of the question that foreign investors should continue to pour money into South American electrical enterprise if there is no return whatever from the capital. The question, therefore, arises what is a really sound compensation for power development in South America. Local conditions of course must be of decisive influence upon rate making, but in considering South American proposals, it is well to estimate always at a comparatively higher development cost than that to be estimated in the United States.

Notwithstanding such local difficulties, there is evidence of an increasing demand for power all over South and Central America leading to many new installations and the extension of others.

Japanese Situation Improves

Trouble has been brewing for a while in Japan, but the principal difficulties seem now to have passed and investors and banks are inclined to take a more hopeful

view of the situation. Japan has suffered principally by over-speculation in some of its most important national products as silk, for instance. Government and foreign financial help has now succeeded in stabilizing the market and the outlook is distinctly improved. The electrical power industry has had its share of the common national difficulties and for a while things looked pretty bleak. The government, realizing the importance of the electrical power industry for the national life of Japan, stepped in, offering not only capital but also plenty of work. A bill was introduced by the railway department for the creation of an imperial railway hydroelectrical company to supply the railroads of Japan with electrical power; 100,000,000 yen will be required for the purposes of this company, of which 70,000,000 yen will be contributed by the government, the rest to come from private investors. This bill is part of the plan of electrifying all the railroads of Japan, a very ambitious scheme which, however, it is much easier for Japan to carry out than for many of the older industrial countries. Its present investment in railroad equipment, etc., is still comparatively small and has not to face the problem of what to do with miles and miles of existing railroads all of which will have to be used up before electrical equipment can be put into place, as is the case in Europe, for instance.

Japan has often been called the England of Asia, being placed like England fronting a large and rich continent. But while England owns large coal resources, the fuel reserves of Japan are comparatively small and certainly are not large enough to sustain a large industry like that expected to grow in Japan. The likelihood of making use of large water powers, therefore, opens new and great possibilities for industrial Japan. More and more preference in consequence is given to the development of hydroelectrical enterprises in the hope of reducing with their aid the coal consumption of Japan's industries. Every month are reported new plans for hydroelectric stations. One of the more recent projects is that of the Taiwan Electrical and Industrial Co. in Taiwan. The co-operation of American capital has been suggested in these enterprises and there is a chance of many of the new Japanese orders to go to the United States provided that an improvement will take place in the political relations of the two large powers.

China, like most other countries of the world, is now emerging from the depression following the war. There is much of interest to power engineers in a recent report by U. S. Trade Commissioner Lynn W. Meekins in Peking. It appears that an American firm has secured good sized contracts for the erection of electric light plants in Changchun and Kirin in Manchuria. The Japanese are very active in Manchuria and have a number of excellently conducted settlements, as that in Mukden, where approximately 16,000 Japanese live. Here are modern hotels, banks, theaters, movies, and electricity is used for street and house lighting. The South Manchurian Railroad is responsible for most of the industrial development in that region. The largest of its power plants is at the Fushun collieries, with a total capacity of 21,500 kw. This power is used for maintaining the tramway system and for coal transportation principally. The same company operates a plan at Dairen with a capacity of 4850 kw., which serves 20,000 houses with 130,000 lights and 26 mi. of electric tramway. Another plant of the same company is located in Changchun. It has a capacity of 1150 kw. and serves 3000 homes with 21,500 lights. In Mukden is a plant of 900 kw., serving 4000 houses with 26,000 lights approximately, and in Antung another one with a capacity of 380 kw.

Political unrest and the war have retarded industrial development in China somewhat, but the war has also had its advantages by forcing China to give more attention to the manufacture of many articles which in the past had not been made in that country. The foundation laid in this manner during the war provides now a stepping stone for future development and there will soon be a distinct demand for industrial power which can best be supplied by electrical energy. What direction power development will take in China is difficult to say. Considering the enormous extension of the country there is comparatively little chance for the erection of hydroelectric power stations, as most of the streams are of an even flow, water falls being found practically only in the interior, where electricity is still not in sufficient demand to make worth while their harnessing. But China has a number of large coal deposits which might easily be used in a similar manner as is now contemplated in England.

China, therefore, will not be in want of industrial power if it once begins to show a decisive demand for it and it is only a matter of time for this demand to arise. American capital has interested itself in many of the electrical undertakings of China. At the present time, however, there is still a predominance of English and in certain regions of Japanese capital.

Power for Asiatic Plantations

Reference has been made in an earlier report of the contemplated development of the Laxapana-Aberdeen hydroelectric scheme in Ceylon. J. M. Mears, the Indian Government expert, has now made a study of this undertaking, resulting in a series of recommendations which have found the approval of the colonial government. Detailed surveys, therefore, will be made of this project. The scheme in its present form contemplates to divert the water of the Kehlgomu Oya and the Maskeli Oya to a point where a head of 2000 ft. approximately can be obtained. 100,000 hp. can be made available in this manner. As the rainfall of the region is not sufficient to sustain the water pressure all through the year, it is further proposed to build a reservoir which can be drawn upon in case of need. The electrical power demand of the district that can be served by this development is not sufficient yet to consume the whole 100,000 hp. and it is, therefore, intended to develop first only one-quarter approximately, leaving the rest of the development to later times when the available power has attracted a sufficient number of consumers to justify an extension.

The plantations region of southern Asia and its islands is still much neglected as regards electrical power development. Those of the plantations which use electrical power as a rule produce it themselves. On the other hand, it is held by experts that the operation of modern plantations like those existing in that part of the world will require much power in the near future. The rubber plantations are already using a great deal of power and the demand is possibly only a matter of supply. One difficulty in supplying power to the planta-

tions is to be found in the considerable size of these undertakings which make necessary extensive distribution lines resulting in a heavy investment in equipment which may not always be justified by the actual requirements of the customer, making the power supply costly for the latter. The good results obtained, however, in British India with the erection of power stations in purely agricultural districts indicate that other parts of southern Asia will soon follow suit and that many new plants will be built in that part of the world.

It is reported from Karachi in British India that the Karachi Electrical Supply Corporation, an English undertaking, is ready to build a new and larger central generation station instead of simply increasing the old one, as was originally contemplated. This new plant will contain steam driven turbo alternators of 1000 kw. each and 6600 v. which will be delivered all through the distributing district inside a radius of 20 mi. from Karachi.

Great preparations are made now in New Zealand to complete the system of hydroelectric plants under public ownership started during the war with the Lake Coleridge plant. This plant has proven such a success that the other important centers of the dominion are clamoring for facilities similar to those accorded to Christchurch and neighborhood. The Lake Coleridge plant produced 33,000,000 kw.-hr. during last year at a cost of $205,589, allowing for a net profit of $17,445. New Zealand is probably today one of the most interesting regions of the world as far as power distribution is concerned. There are at present in operation 71 local plants with a total capacity of 45,805 kw. Seven of these will be enlarged in the near future, adding 33,500 kw. to the available energy and $7,698,000 have been ear-marked for this purpose. Each of the plants is to be joined up with the central hydroelectric plants as soon as this can be made possible. The government contemplates to erect only the hydroelectric central stations and to build the transmission lines. It will sell the power to the local power boards which then will undertake to distribute to the consumer. These power boards are local public bodies and erect their own distribution plants, finding the money by the issue of local loans to the general investor. It is now proposed to standardize the entire electric development of the dominion upon the basis of a 3-phase, 50-cycle system. All new equipment will be specified upon this system. All in all, there are approximately 700,000 hp. of hydroelectrical power available, which is practically evenly distributed over both islands. The total cost of utilizing this power is estimated to be $50,000,000. For the current year $3,200,000 have been allotted for new and additional construction.

It is not expected to finance the whole of this scheme in New Zealand and efforts will be made to place loans with foreign manufacturers of electrical equipment. Some of the equipment used by the government is already of American make and there are hopes that larger orders will be placed with American electrical firms provided that American banks can be interested in supplying funds for such a transaction.

He who thinks he knows it all does not know enough to learn anything worthwhile.

Viscosity of Engine Oils

Greasy Friction Essential for Reciprocating Engine. By O. W. Franke

Lubrication of the steam engine bearings presents problems quite different from those encountered in the lubrication of the steam turbine. In the latter, the shaft runs at a sufficiently high speed to build up an oil pressure in the bearing clearance high enough to float the shaft on a perfect film of oil. Furthermore the oiling system almost always is so completely enclosed that the oil does not become contaminated with very much foreign material; it is cleaner and is better enabled to maintain its original condition.

In the steam engine, the shaft speed is comparatively slow and it does not draw the oil into the clearance space between the shaft and its bearing fast enough to build a pressure sufficient completely to float the shaft. Probably in no case does full floating lubrication ever occur in steam engine bearings, especially in view of the fact that the load is variable, changing from one side of the bearing to the other. As a result, there is always a condition of partial metallic rubbing of the shaft on its bearing along a line determined by the resultant of the forces due to the weight of the flywheel and shaft and the power delivered by the connecting rod.

This means that the laws of lubrication applicable to the steam turbine cannot be used for the steam engine, but instead the laws of greasy friction must be considered. By this is meant the friction developed when two surfaces thoroughly saturated with a lubricant rub together without having a sufficient film of oil between them to hold them completely apart. Such is always the case with the reciprocating parts of the engine such as the cylinder and crosshead guides.

Under what is called greasy friction, lubrication is secured by the development or formation of a greasy film on the metal surfaces by the absorption of the oil into the pores of the metal, filling up the spaces, making a smoother surface and covering over the high spots. A broken piece of bearing metal always shows very clearly the depth to which the oil has been absorbed.

In testing various types of lubricants under conditions of greasy friction, experimenters have found that there is a decided difference in the friction resulting from the use of various kinds of oils, even though they may have exactly the same viscosity. A possible explanation of this phenomenon may be that the oil, when it is absorbed by the metal, forms some chemical compound with the metal, which decreases the friction of the surfaces. The character of the compounds so formed, varying with the oil used, may account for the frictional difference, or the so-called quality of unctuousness. This characteristic of the oil is apparently entirely independent of the viscosity, and probably varies with the kind of metal.

Any engineer can prove to himself that this formation of a compound of some sort actually occurs, by carefully examining the walls of a steam cylinder. He will find that, if properly lubricated, a highly polished surface has been formed. If the cylinder oil is changed to one of a different character, it will be found that this glaze will disappear and the cylinder wall will appear rough for a few days until a new surface or skin has been formed with the new oil. Apparently there has

been some sort of a compound formed in the pores of the metal which gives a bright, smooth surface. The same thing occurs, no doubt, in the bearings, the difference in the character of the compound formed by various metals accounting for the decreased frictional resistance when the two rubbing surfaces are of different materials.

Since full floating lubrication always produces less friction than partial lubrication, due solely to metal absorption of the oil, it is always desirable to approach this condition as nearly as possible even though it may not be perfectly accomplished, hence the value of the circulating oiling system in reducing friction. A large quantity of oil, supplied to the bearing, provided the clearances are sufficiently large, will produce a certain amount of pressure within the bearing to prevent the shaft from touching the bearing except along a very narrow line at the point of heaviest load. This condition of partial floating lubrication is certainly more advantageous than complete metallic rubbing, even though the surfaces be thoroughly saturated with lubricant.

With these conditions in mind, it might appear that the viscosity of the oil is not such an important factor after all, but such is not the case. In the case of engines not provided with circulating systems, the viscosity of the oil, or its fluidity, affects the length of time that the oil will stay in the bearing. This regulates the waste of oil from the bearing and the frequency of further applications—a heavy oil will last much longer than a light oil and there will be less danger of hot bearings from lack of oil.

While the same thing holds true for bearings equipped with a continuous circulating oiling system, the flood of oil supplied to the bearings makes it unnecessary for the oil to remain in the bearing for any length of time. Furthermore the flood of fresh oil lowers the temperature by carrying away the generated heat, keeps the bearing clean and reduces frictional losses.

When the circulating system is used, much lower viscosities are satisfactory and more desirable than high viscosities for a number of reasons. In the first place, a thin oil will separate from water more quickly than a thick oil. There is always a certain amount of moisture in the circulating system of a steam engine from cylinder condensation leaking past the stuffing-boxes, absorption from the air, leaky cooling coils, etc. Certain types of filters always have water in them and the oil coming in contact with the water picks up and retains a certain amount of it.

As the low viscosity oils separate from water much more quickly than the high viscosity oils, they are a decided advantage when rapid circulation is necessary. In fact, there is such a marked improvement in the separation qualities of the low viscosities that the oil is frequently thinned down by heating, to allow it to separate properly from water and other impurities in the system. Heavy oils are more likely to cause emulsions, pick up and carry abrasive material to the bearings, increasing wear and raising the temperature.

Any oil, when subjected to rapid circulation, agitation and heat in the presence of air will vaporize and oxidize to a certain extent. On this account, the oil in any circulating system will increase in viscosity with use and unless given proper attention may become so heavy as to be of little value. Consequently it is desirable to check the viscosity of the oil at frequent intervals and if it is found that it is becoming too viscous, it should be reduced by the addition of lighter oil.

The viscosity of the oil in the circulating system should range between the limits of 150 and 200 seconds Saybolt Universal. If it goes much above 200 seconds there will be an unnecessary load imposed on the filtering system and unless proper provisions are made, it will not be cleaned satisfactorily. The lower figure of 150 seconds is a much more desirable viscosity to maintain.

While it is quite true that under normal conditions the lighter viscosity oil may have a higher evaporation loss than a heavier oil, experience has shown that the reduced losses in the filters and the general improvement in lubrication will more than offset it.

The Superpower Zone

Data of Present Equipment and Requirements

REPORT has just been made by the Census Bureau on the power equipment and fuel consumption of plants in the North Atlantic superpower zone, in collaboration with the Superpower Survey. The zone embraces southern New Hampshire and Vermont, the balance of southern New England, eastern Pennsylvania, southeastern New York, New Jersey, District of Columbia and part of Delaware.

Of the 96,000 establishments reported, 79.4 per cent used power aggregating over 9,000,000 hp., primary and purchased. Of this 4,255,868 hp. was furnished by 33,379 steam engines; 1,171,061 hp. by 2115 steam turbines; 279,040 hp. by 6246 combustion engines; 541,033 hp. by 4708 water wheels. In secondary power, 2,770,715 hp. was purchased for use in 361,961 electric motors; and 2,565,912 hp. was used in 198,961 motors drawing from their own generating stations; while 51,754 hp. was purchased for compressed air and belt-and-shafting transmission. This gives 58.8 per cent of the total power as being utilized in electric motors.

Of fuel, 20,910,000 T. of anthracite, 34,669,000 T. of bituminous and 5,661,000 T. of coke were used as of 1919.

The industry using the largest amount of power is textiles, a close second is iron and steel, while mines, paper and printing, chemicals, non-ferrous metals, stone and clay, and lumber also use large amounts.

In fuel used, however, the chemical industry ranks first, iron and steel second, textiles third, mines fourth, stone and clay fifth, and food products sixth; other large users being paper, non-ferrous metals, railroad repair shops, beverages and leather.

The Motorman Is a Non-Conductor, Jerry

JERRY. 'Tis a funny thing oi saw in a book last night. Sure the man says: "Electricity flows through conductors."

Quinn. Phat's funny about thot?

Jerry. Why, ye blockhead, what has the conductor got to do wid runnin' the car? 'Tis sure and certain the writer must have meant the motorman.

Solution of Heat Transfer Problems

GRAPHICAL METHOD OF DETERMINING MEAN TEMPERATURE DIFFERENCES. BY H. G. NEVITT

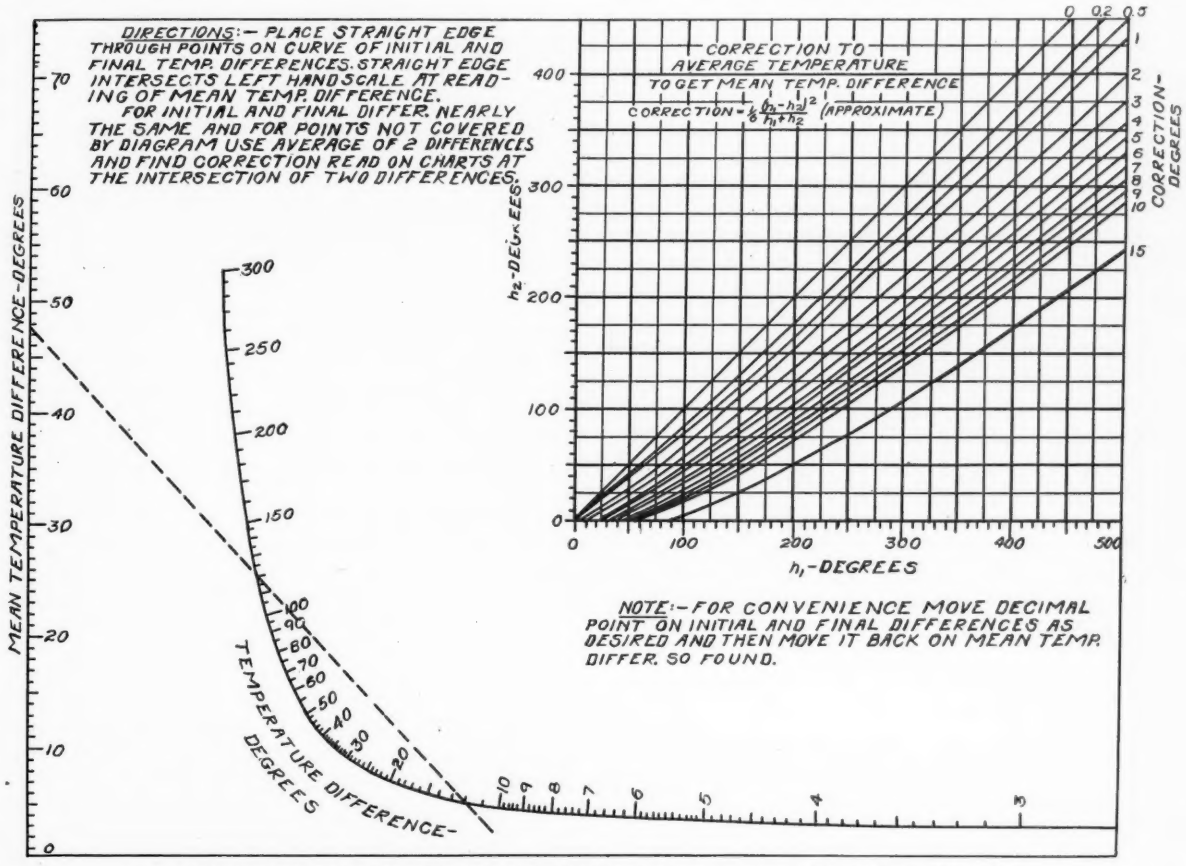
HEAT TRANSFER is an important subject in practically all lines of mechanical work. Heat apparatus is very commonly used and its growing application in industrial engineering is making this branch of technology more and more important. This increase in our heat transfer work is not merely in quantity, but also in variety and scope of the problem involving the fundamental relations of the subject.

Heat transfer problems require a considerable amount of computation. This is mainly due to the form of the equation which expresses the relation between some of the quantities involved, but an additional difficulty under some special cases is that a solution by trial is necessary in practice.

The first relations are simple in nature, but these latter are more complicated and are the ones in which, in consequence, we are interested. These latter relations can be represented in a comparatively simple form and for all types of flow, either parallel flow or counter-flow, and for all cases of heat exchange, whether the specific or latent heat of the substances in question is involved in the relation, by the equation

$$h_m = \frac{h_1 - h_2}{\log_e \frac{h_1}{h_2}}$$

where h_m = the mean temperature difference, h_1 = the initial temperature difference, h_2 = the final temperature difference, the largest temperature difference being considered in every case the initial one, and if H = total quantity of heat transfer, S = transfer surface, U = coefficient of heat transfer, then $H = h_m U S$.


DIRECTIONS:- PLACE STRAIGHT EDGE THROUGH POINTS ON CURVE OF INITIAL AND FINAL TEMP. DIFFERENCES. STRAIGHT EDGE INTERSECTS LEFT HAND SCALE AT READING OF MEAN TEMP. DIFFERENCE.
FOR INITIAL AND FINAL DIFFER. NEARLY THE SAME AND FOR POINTS NOT COVERED BY DIAGRAM USE AVERAGE OF 2 DIFFERENCES AND FIND CORRECTION READ ON CHARTS AT THE INTERSECTION OF TWO DIFFERENCES.
CORRECTION TO AVERAGE TEMPERATURE TO GET MEAN TEMP. DIFFERENCE
CORRECTION = 1/6 ((h1-h2)/(h1+h2))^2 (APPROXIMATE)
MEAN TEMPERATURE DIFFERENCE-DEGREES
h2-DEGREES
h1-DEGREES
CORRECTION-DEGREES
TEMPERATURE DIFFERENCE-DEGREES
NOTE:- FOR CONVENIENCE MOVE DECIMAL POINT ON INITIAL AND FINAL DIFFERENCES AS DESIRED AND THEN MOVE IT BACK ON MEAN TEMP. DIFFER. SO FOUND.

STRAIGHT LINE DIAGRAM FOR MEAN TEMPERATURE DIFFERENCE IN TRANSFER OF HEAT

A number of questions enter into the determination of the best method of solving heat transfer problems. The relations between the quantities involved are of two general types. One involves the heat transfer quantities, maximum temperatures and other factors upon which the initial and final temperatures of the fluids or materials to be considered are dependent and the former generally being known, the latter can be found. The other involves the initial and final temperatures of the fluids interchanging the heat, the coefficient of heat transfer and the transfer surface.

Another question is the type of computation necessary; that is, whether it should be exact or more or less approximate. Data on heat transfer are never very exact; in fact, often much the opposite. In consequence, accuracy in computation is not usually required; hence, often, the arithmetical or approximate mean can be de-

termined and corrected by judgment resulting from a little experience with this type of computation. The writer has often done this and finds that a shrewd guess as to the correct mean temperature difference can be made, knowing the arithmetical mean, that is sufficiently accurate and usually far more so than the data or assumptions used in the computation. If this is not considered desirable, the use can be made of either direct calculation by slide rule or tables or by graphical methods which then will be in general as accurate as required. It will be found that the main reason for accurate is in computation where the heat balance is made as a check. In this case, the data assumed, while perhaps not accurately expressing the circumstances occurring, will be so taken as to check in itself, and in consequence, computations from it must be made with reasonable accuracy so that they will check with each other also; however, such a condition is not very common. It may be said that the main reason for making the computation accurate is that except for the estimating referred to above, it can be done to a reasonable degree just as easily as to make it very approximate.

In connection with the use of the arithmetical mean: there seems to exist some misapprehension among engineers who have not looked up this subject, that the arithmetical mean for the initial and final temperatures is the same as the mean temperature difference, but reference to any standard work will show that this is not the case; however, the two figures often agree very closely with each other, as will be found by taking a number of typical cases and computing the two quantities for assumed values of h_1 and h_2.

Obviously, if all the other relations are simple and involve only multiplication or division or similar operations, the easy computation of heat transmission problems depends only upon finding a quick way of determining the values of either h_m, h_1 or h_2 when the other two of them are known. The relation between them in the form given is not well adapted to calculation nor is the form of the equation one commonly met with and handled in a number of graphical ways. It required some searching to work out a method whereby a graphical solution of this calculation could be made, using a straight line diagram.

If the equation, $y = xe^{1/x}$ is plotted

where $x = 1/\log_e h$

$$y = hx = h/\log_e h$$

and h is laid off on the Y axis, it will be found that if a straightedge is laid on the points x_1, x_2, corresponding to the value h_1, and x_2, y_2, corresponding to the value h_2, that it will intercept the y axis at a value

$$h_m = \frac{h_1 - h_2}{\log_e \frac{h_1}{h_2}}$$

In other words, the intercepted h_m so read is the mean temperature difference desired for the values h_1, h_2. Such a curve is shown with the values for reading h_1 and h_2 shown directly on the curves.

By the use of such a diagram, the mean temperature difference can be immediately found. This diagram is good for the most usual cases where h_1 and h_2 are very different in amount and is quite accurate in such cases. Where h_1 and h_2 are nearly the same value, the diagram is not so good because the mechanical error of placing the straightedge intersecting two points very near each other on the curve, as would occur in such case, is liable to be appreciable. In such cases, however, the arithmetical mean of the initial and final differences will be found to be almost equal to the true mean temperature difference.

In cases where this latter circumstance arises and yet more accuracy is desired than would result using the arithmetical mean, an auxiliary chart will be found useful. This chart shows the correction to be subtracted from the arithmetical mean to obtain the true mean temperature difference, as in every case the arithmetical mean is the largest. This correction is approximately equal to

$$1/6 \frac{(h_1 - h_2)^2}{(h_1 + h_2)}$$

and the mean temperature difference is then

$$h_m = \frac{h_1 + h_2}{2} - \text{correction.}$$

This formula for the correction was obtained by expanding the formula for it as a series and omitting all the other terms of the series which are negligible. As it is not adapted to the straight line form of diagram, the correction chart was made up with the usual rectangular co-ordinates. Due to the fact that the correction is small compared to the quantities involved, it can be read very accurately, and since the arithmetical mean can also be determined with considerable accuracy without much trouble, this offers a very accurate solution for the case, provided the quantities h_1 and h_2 are close together in value; in other words, that the correction is comparatively small and hence the approximate formula given for the correction is true to a very small percentage of error.

Some points in the use of this diagram: The values plotted are for the usual range of temperature encountered, and it is immaterial, of course, whether these are expressed in Centigrade or Fahrenheit or any other system. It will be seen, however, that if h_1 and h_2 are divided through by any one quantity and the h_m from the figures so resulting obtained and multiplied by this same quantity, it will be the mean temperature difference desired. For example: we can mark off the decimal point on h_1 and h_2 and mark it back on the h_m resulting; however, we must be careful not to perform this operation on only one of the two determining quantities used, as it will then be incorrect; that is, mark it off on h_1 alone for instance. In this way, the chart can be used for practically any range of values encountered.

Another point is that the charts should be used properly, the straight line diagram being generally employed unless h_1 and h_2 are close together, in which case the arithmetical mean and the correction should be used.

In concluding, it may be said that this gives a ready, graphical chart for determining the mean temperature difference in a heat transfer problem when the initial and final temperature differences are known and that the error of calculation is far less than that of the experimental data or the requirements of the calculation in general.

Utilization of Back Pressure in British Power Plants

ECONOMICAL CONSIDERATION AND METHODS EMPLOYED. BY C. H. S. TUPHOLME

IN a report to the Manchester Steam Users' Association W. C. E. Stromeyer, chief engineer, says that although the principles on which heating by means of exhaust steam from engines are based are well understood, it seems advisable, on account of the somewhat complex nature of the subject, to re-state these with the help of few simple diagrams. The heat equivalent of one horsepower-hour (550 ft.-lb. per sec.) is 2540 B.t.u. It can be represented by the heat contained in 2 lb. of high-pressure superheated steam, or by the heat of combustion of 0.2 lb. of ordinary coal of, say, 12,700 B.t.u. heat value.

It is very desirable to disabuse our minds of the notion that 10, 20 or more pounds of steam per hour are one horsepower. Steam is merely the conveyor of power, as copper wire is the conveyor of electricity. This conveying power is limited. For instance, a copper wire would fuse if too much electricity were passed through it, and in practice a limited quantity, say, one or two thousand amperes per square inch, is found practicable. Similarly with regard to steam and power. One horsepower is represented by the evaporation or condensation of about two pounds of water or steam per hour, but in practice more than 10 and sometimes up to 50 lb. of steam have to pass through an engine to produce one horsepower. The heat contained in this large quantity of steam is wasted, all except that represented by 2.1 lb. of high-pressure steam. It is either blown into the atmosphere or into the condenser. Back-pressure systems aim at utilizing this enormous waste for heating purposes. A customary condensing engine of, say, 100 hp. is represented by Fig. 1.

A high-pressure non-condensing engine of 100 hp. is represented in Fig. 2.

If instead of 60 lb. absolute back pressure, as assumed in Fig. 2, 30 lb. absolute or 15 lb. above atmosphere were to be adopted, the weight of exhaust steam per hundred horsepower would be about 5300 lb. instead of 7190, the steam supply to the engine 5510 lb., the chimney waste 2360 lb., and the heat supply to the boiler would be equivalent to 7870 lb. of steam, say, 730 lb. of ordinary coal.

In Fig. 2 there would be available for heating purposes at 45 lb. pressure, or 292 deg. F., about 7190 lb. of steam per hour, capable of heating about 3600 gal. of water per hour to boiling point.

In the second case, the available pressure would be 15 lb., with a temperature of 250 deg. F., and its heating capabilities would be 2650 gal. per hour. In both cases, the 100 hp. would cost practically nothing, viz., 210 lb. of steam, or 20 lb. of ordinary coal. In other words, when all the steam can be utilized for heating or other purposes, the power derived from it costs practically nothing. It is, therefore, obviously highly economical for those plants which use much steam for heating, to produce power with it and use or sell it; and those works which produce much power might sell their waste steam for heating purposes.

Those cases in which the heating requirements are greater than can be obtained from the engine exhaust, although relatively few in number, are of great importance, and as in these works there is much scope for electric heating, it is desirable to consider whether some of the exhaust steam could not be converted into electricity. Assume that one of these works requires an effective back pressure of 15 lb. and 5300 gal. of boiling water per hour. Two engines of 100 hp. each could be run in these works, the one driving the machinery either direct or by means of electricity, and the other producing electricity for heating purposes, equal to an additional 105 gal. of boiling water. Heating by electricity, especially when it costs practically nothing, has many advantages. High-pressure steam vessels in the midst of factory hands could be dispensed with, and any desired

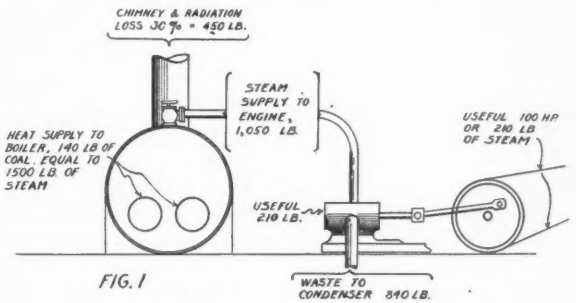

CHIMNEY & RADIATION LOSS 30% = 450 LB.
STEAM SUPPLY TO ENGINE, 1,050 LB.
HEAT SUPPLY TO BOILER, 140 LB. OF COAL EQUAL TO 1500 LB. OF STEAM
USEFUL 210 LB.
USEFUL 100 HP OR 210 LB OF STEAM
WASTE TO CONDENSER 840 LB.

FIG. 1

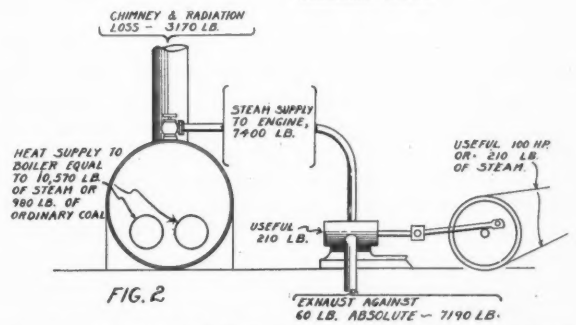

CHIMNEY & RADIATION LOSS = 3170 LB.
STEAM SUPPLY TO ENGINE, 7400 LB.
HEAT SUPPLY TO BOILER EQUAL TO 10,570 LB. OF STEAM OR 980 LB. OF ORDINARY COAL
USEFUL 210 LB.
USEFUL 100 HP OR 210 LB. OF STEAM.
EXHAUST AGAINST 60 LB. ABSOLUTE = 7190 LB.

FIG. 2

FIG. 1. DIAGRAM OF HEAT LOSSES IN CONDENSING POWER PLANT

FIG. 2. DIAGRAM OF HEAT LOSSES IN PLANT USING EXHAUST STEAM AT 60-LB. PRESSURE

temperature could be attained without having to contaminate the air with burnt gas. Therefore, in all those works where direct heating is done by low-pressure boilers, there is a probability that much heating might be done by electricity without extra cost.

The majority of works require less heat than that which is at present discharged by their driving engines. Assume a case where the available back pressure has to be 15 lb.; then if the heating requirements are 4500 lb. of steam, it would, from an economic point of view, make no difference whether these 4500 lb. of steam were drawn direct from the boiler, costing the equivalent of 6370 lb. of steam plus 1500 lb. for producing 100 hp. (total 7870 lb.), or whether the exhaust steam from the engine were used, which, as shown above, amounts to 7870 lb. In this case, of course, the difference between 5300 and 4500 = 800 lb. of steam, would be blown to

waste, and the idea naturally presents itself that this portion of the steam should not enter into the back pressure main at all and, therefore, not through the non-condensing engine but should be passed through a highly efficient condensing engine. This is essentially the principle on which extraction engines are designed.

Before deciding whether a back-pressure system of heating is to be adopted it is essential to know the steaming and heating requirements of a factory. If they exceed 20 to 25 gal. of boiling water per hour per horsepower, then a back-pressure engine should be advantageous; if the requirements are less, then an extraction engine, or live steam heating combined with a very efficient engine, is more economical, but the engine has to be very economical.

In practice, the fuel expenditure is more often above 2.8 lb. of coal per one horsepower than 1.4 lb., as here assumed, whereby the relations are materially modified. The limit between the use of live steam and back pressure steam would, therefore, in practice be reached when the heating requirements are about 15 to 20 gal. per hr. per indicated horsepower. Of course, wherever non-condensing engines are used, it is certainly advantageous to employ the exhaust steam for heating purposes.

The difficulty of deciding on the best plan to be adopted is due generally to ignorance as to the relative steam consumptions in engines and heating appliances; but the ever-increasing accuracy of steam meters should make it possible nowadays not only to measure steam consumption for reorganization purposes, but also subsequently to check the waste of individual steam consumption appliances.

Manufacturers who may wish to utilize their back pressure for heating purposes will have to consider the the question of adapting their engine to this purpose or whether it would be advisable to replace it by a back-pressure turbine. A rough but reasonably accurate rule is that a condensing engine working 60 r.p.m. develops from 8 to 10 hp. per cu. ft. of low-pressure cylinder. If this cylinder should be used for high-pressure steam, it should develop 16 to 20 hp. per cu. ft. plus 25 per cent for the high-pressure cylinder in the cases of compound engines. This estimate applies to engines in which the absolute back pressure is about one-third of the absolute boiler pressure. It has to be reduced by about 25 per cent if the back pressure is one-half of the boiler pressure.

There is, therefore, no difficulty as regards size of engine in changing from the condensing principle to the back-pressure principle, but most low-pressure cylinders are very weak and would have to be replaced by stronger ones of the same or smaller dimensions. When such a change is under consideration, the advantage of using a back-pressure turbine should not be overlooked. The advantage is that the exhaust steam is not contaminated with grease and can be blown direct into the water to be heated, without the intervention of heaters and coils of pipes.

The cylinders of a simple high-pressure condensing engine will always be both large enough and strong enough for conversion into a back-pressure engine.

In some works much power and steam are required during the day, and little power, but the same quantity of steam, at night. These cases could usually be met by lowering the pressure during the night and using steam direct from the boilers. The reverse conditions—power night and day and steam for heating during the day—could be met by bifurcating the exhaust and fitting two large valves, one opening to the condenser and the other to the back-pressure system. With compound engines the arrangement is more complicated.

Many recommendations have been made to extract steam for heating purposes from the engine at some convenient intermediate pressure. Theoretically, as already pointed out, a saving can be effected by this means, but unless the demand for steam for heating is steady, this system introduces fluctuations into the engine speed which cannot well be met, except by the use of two governors. The nature of this difficulty will be apparent by once more glancing at the back-pressure engine. Assume that a back-pressure engine is being supplied with steam of 150 lb. absolute and exhausting against a pressure of 60 lb. absolute, then if the demand for power be increased, the governor would increase the steam supply by shifting the cutoff; but this increase would also increase the back pressure and, under certain relations of pressures, the result would be a reduction of power. Then, also, if there should be a sudden heavy demand on the back pressure steam, the power would naturally increase above requirements and the governor would reduce the steam supply and cause the back pressure to sink still further. This difficulty can be met, within limits, by throttling the exhaust, but in a paradoxical way, the exhaust throttle valve having to be closed more and more as the back pressure sinks. The first effect would be to reduce the power, but then, of course, the inlet governor would admit an extra quantity of steam as required. In other words, the greater the demand for back-pressure steam, the horsepower remaining constant, the more efficient will the engine have to be made, and the simplest plan for doing this is to raise the back pressure. The several pressures can, of course, be regulated by the cutoff and exhaust, or, rather, compression arrangements.

Supplementary means for maintaining a reasonably constant back pressure is to install throughout the works in convenient situations large thick-walled vats or metal reservoirs thoroughly protected against heat loss by radiation, and to use these reservoirs for storing hot water. Here also two regulators would be necessary, one for shutting off the cold water supply whenever the temperature of the contents approached 212 deg. F., and one for increasing the steam supply with increasing back pressure. If ordinary oily engine exhaust be used, the reservoir water will have to be heated by means of steam pipes, and then provision must certainly be made for thoroughly scraping all cylinder oil out of these pipes. If the back-pressure turbines are used, the steam can be blown direct into the reservoir waters.

In very many works reservoirs of boiling water would effect a great saving of time, would eliminate inconveniences, and in chalky districts the heating of the water would precipitate most of the lime salts. With a 6 or 9-in. non-conducting covering for these tanks, their loss of heat should not exceed about 0.05 lb. of steam condensed per square foot per hour. A cylindrical vessel 6 ft. diameter and 10 ft. high, holding about 16 tons of water, should therefore not lose more heat than is represented by the condensation of 12 lb. of steam per hour, corresponding to a reduction of temperature

of this vessel when full, of about 3 deg. F. per hr. A 16 hr. overnight period would result in a reduction of less than 50 deg. F., and 180 lb. of steam blown into the reservoir or into its heating pipes would re-establish a temperature of 212 deg. F.

Tannic Acid in Concrete

IT IS important that concrete used for plant buildings or foundations should have full strength, hence the results of tests made at Lewis Institute by Professor Duff A. Abrams acting with the Portland Cement Association to ascertain the effect of organic matter in concrete are of vital interest.

In order to get definite values, tannic acid, the active element which would be found in organic matter, was mixed with the aggregate in quantities up to 0.4 of one per cent by weight, and compression tests made on concrete cylinders made from this aggregate 3 by 6 in., the mix varying from 1 to 5 up to 1 to 2, and size of aggregate from a fine mixture up to ¾ in. graded. Specimens were stored in damp sand, and tested at the end of 1 week, 4 weeks, 3 mo., 1 yr. and 2 yr., about 2000 tests being made. The process of the tests and results are published as Bulletin 7 of the Structural Materials Research Laboratory, Lewis Institute, Chicago.

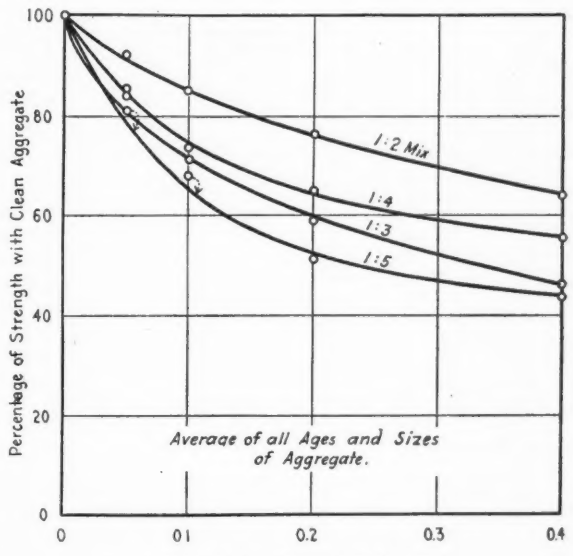
Checking these tests against those on natural sands containing organic matter, it was found that the effect of the tannic acid was typical of that produced by the organic matter.

Lean mixtures are more affected than rich ones, but the strength of all mixes, of all ages was reduced for all percentages of tannic acid. Acid to less than 0.1 of one per cent of the weight of the aggregate may reduce the strength to half its normal value, mixtures of fine aggregates being less affected than those from coarse, and wet consistencies being less affected than drier ones.

Reduction of strength depends on the concentration of tannic acid in the mixing water, and is greater in proportion for small percentages of acid than for higher ones. The effect of the acid decreases with aging of the concrete.

The conclusion is that surface loam and organic matter should be carefully removed from concrete sands, which can generally be done by thorough washing. Test for organic impurities may be made by shaking a sample of the sand thoroughly in a dilute solution of sodium hydroxide (NaOH) and observing the color after the mixture has stood a few hours. Fill a 12-oz. graduated bottle to the 4.5-oz. mark with sand; add 3 per cent solution of NaOH until the volume of the mixture, after shaking, stands at the 7-oz. mark. Shake thoroughly and let stand 24 hr. If the solution is then colorless or a light yellowish, the sand will be satisfactory. If a dark solution results, the sand should be used for concrete only after mortar-strength tests have shown that it will be satisfactory for the work contemplated.

The tests showed that strength of the concrete is rapidly reduced with the increase of water-ratio (the ratio of water volume to loose volume of cement in the batch) for all ages, all mixes and all percentages of tannic acid. The accompanying curves show the reduction in strength for different percentages of acid, taking the average of all sizes of aggregate and all ages of specimens.



REDUCTION IN STRENGTH OF CONCRETE FOR DIFFERENT PERCENTAGES OF ACIDS

Taking the average of all mixes and all aggregates, it was found that at 7 days 0.1 per cent of acid reduced the strength of the concrete about 33 per cent; at 28 days, about 30 per cent; at 1 and 2 yr. about 20 per cent.

Cleaning Coal By Flotation

FOR cleaning fine coal, a new flotation process is now being tried in England. This consists of reducing all coal to a size that will pass a 10 mesh to the inch screen, mixing it with 3 to 4 times its weight of water and with an oil or coal tar product, about 1 lb. per ton of coal. The mixture is agitated by a power-driven mixer, producing minute air bubbles, to which the coal particles become attached and are floated to the surface, where the coal is scraped off, the dirt and ash forming material sinking to the bottom whence they are drawn off and discarded. The material is passed through a series of three mixing boxes and three froth boxes, all of wood construction, a plant to treat 1000 t. a day being 37 ft. by 15 ft. 9 in. by 15 ft. 6 in.

For a typical washing the results were as follows:

PERCENTAGES IN RAW AND WASHED COAL

	Weight	Ash	Fixed Carbon	Volatile
Raw	100	29.55	48.2	22.35
Washed	75.1	9.86	60.24	29.90
Residue	24.9	82.45	2.75	14.80

CHRISTIAN AUGUST THORNE, president of the building committee for the Morkfoo-Solberfoss electric power station being erected near Christiania, in a recent article on "Norway's White Coal" estimates the total amount of water power in Norway as between 13,000,000 and 15,000,000 hp. Of this tremendous amount only about 1/10 has been utilized, hence it is that much power awaits the man that will harness and drive it.

Determining Steam Flow by Pressure Drop*

Two Steam Gages, Straight Run of Pipe and Babcock's Formula Will Give Steam Flow. By V. F. Davis

TO FIND the weight of steam flowing through a pipe, it is not always necessary to use a flow meter. Nor is it necessary to condense the steam and weigh the condensate. Nor is it even necessary to watch the boiler gage glass and attempt roughly to "compute" steam flow, as is sometimes done in spite of the great inaccuracy of the method. Steam flow can be determined, and without great difficulty, by the simple application of Babcock's steam flow formula.

A purchaser of steam, for instance, wishes to know the weight of steam that is flowing through a certain pipe line to one of his steam using departments. He would like to install a flow meter, but hesitates on account of the high cost of the meter, hence he never knows even approximately the amount being used.

All that is necessary in a case of this kind is to select a straight run of pipe and tap two ordinary but accurate pressure gages into the pipe a known distance apart. The farther apart the better. Then, knowing the exact internal diameter of the pipe and the simultaneous pressure gage readings on the two gages, the determination of steam flow becomes a mere matter of applying Babcock's formula which is

$$W = 87\sqrt{\frac{pDd^5}{\left(1+\frac{3.6}{d}\right)L}}$$

where W = the weight of steam flowing through the pipe in pounds per minute.

p = the difference in pressure between the two gages in pounds per square inch,

D = density of the steam or weight in pounds of one cubic foot of steam at the mean average between the two gages—see Table I;

d = actual internal diameter of pipe in inches—see Table II;

L = distance between the two pressure gages in feet.

For example, two pressure gages are placed on a 1-in. pipe line, 100 ft. apart. One registers 5 lb. and the other 15 lb. pressure. How many pounds of steam are flowing through the pipe?

To solve the problem, we must know the pressure difference p, which is:

$p = 15 - 5 = 10$ lb.

To find D, the "average" steam pressure must first be determined. In this example the average therefore is:

$$\frac{15+5}{2} = 10 \text{ lb.}$$

Referring now to Table I of mean densities we find that

$D = 0.0606$.

Inasmuch as it is desirable to know the exact internal diameter of the pipe rather than the approximate diameter, the writer is including herewith Table II which is based on standard pipe data.

TABLE I
DENSITY OF STEAM

Steam Pressure in lbs. per sq. inch Gage	Weight of Steam per Cu. Ft. in pounds
1	.0396
5	.0490
10	.0606
20	.0834
30	.1058
40	.1278
50	.1497
60	.1715
70	.1930
80	.2141
90	.2358
100	.2570
120	.3003
150	.3636
200	.4672
250	.5714

TABLE II
STANDARD PIPE DATA

Nominal Pipe Size	Internal Diameter,	$d^5 \div \left(1+\frac{3.6}{d}\right)$
¼	0.622	0.013,71
¾	0.824	0.070,73
1	1.049	0.286,6
1¼	1.380	1.387
1½	1.610	3.343
2	2.067	13.73
2½	2.469	37.33
3	3.068	125.09
3½	3.548	276.16
4	4.026	558 45
4½	4.506	1,032.57
5	5.047	1,911.6
6	6.065	5,151.5
7	7.023	11,298.9
8	7.981	22,308.7
9	8.941	40,754.6
10	10.020	74,322.3
12	12.000	191,408
14	14.250	469,321
15	15.250	667,297

This table gives the actual internal diameters d and, to save time for the reader, values of

$$d^5 \div \left(1+\frac{3.6}{d}\right)$$

which appears in the formula as a constant for each pipe size.

Taking values from Table II we therefore have from column 3: 0.2866.

Then substituting the known values in the Babcock formula, we now get

$$W = 87\sqrt{10 \times 0.0606 \times 0.2866 \div 100}$$
$$= 3.62 \text{ lb. of steam per minute.}$$

For solving Babcock's formula, the accompanying chart has been designed. In using the chart, a straightedge is placed at the proper point in the scale of lengths and passed through the point in the scale of pressure differences representing the drop in pressure between the two gages, the line being extended until it crosses the blank axis. From this point the straightedge is turned until it passes through the scale of steam pressures at the point representing the average pressure between the two gages, the line being extended until it crosses the second blank axis. The straightedge is rotated on this second point as a pivot until it passes through the scale of pipe diameters at the point representing the nominal pipe size; this line extended will pass through the scale of steam flow at the point representing the weight of steam flowing per minute.

All the calculations necessary when using the chart are to find the difference in pressure as indicated by the gages and the mean steam pressure as have already been explained; all other factors, constants, corrections, etc., have been taken account of in the design of the chart. To illustrate the use of the chart, the problem given above is worked out as shown by the broken lines.

*All rights reserved for a forthcoming book on reducing valves, by the Atlas Valve Co., with whom the author is associated.

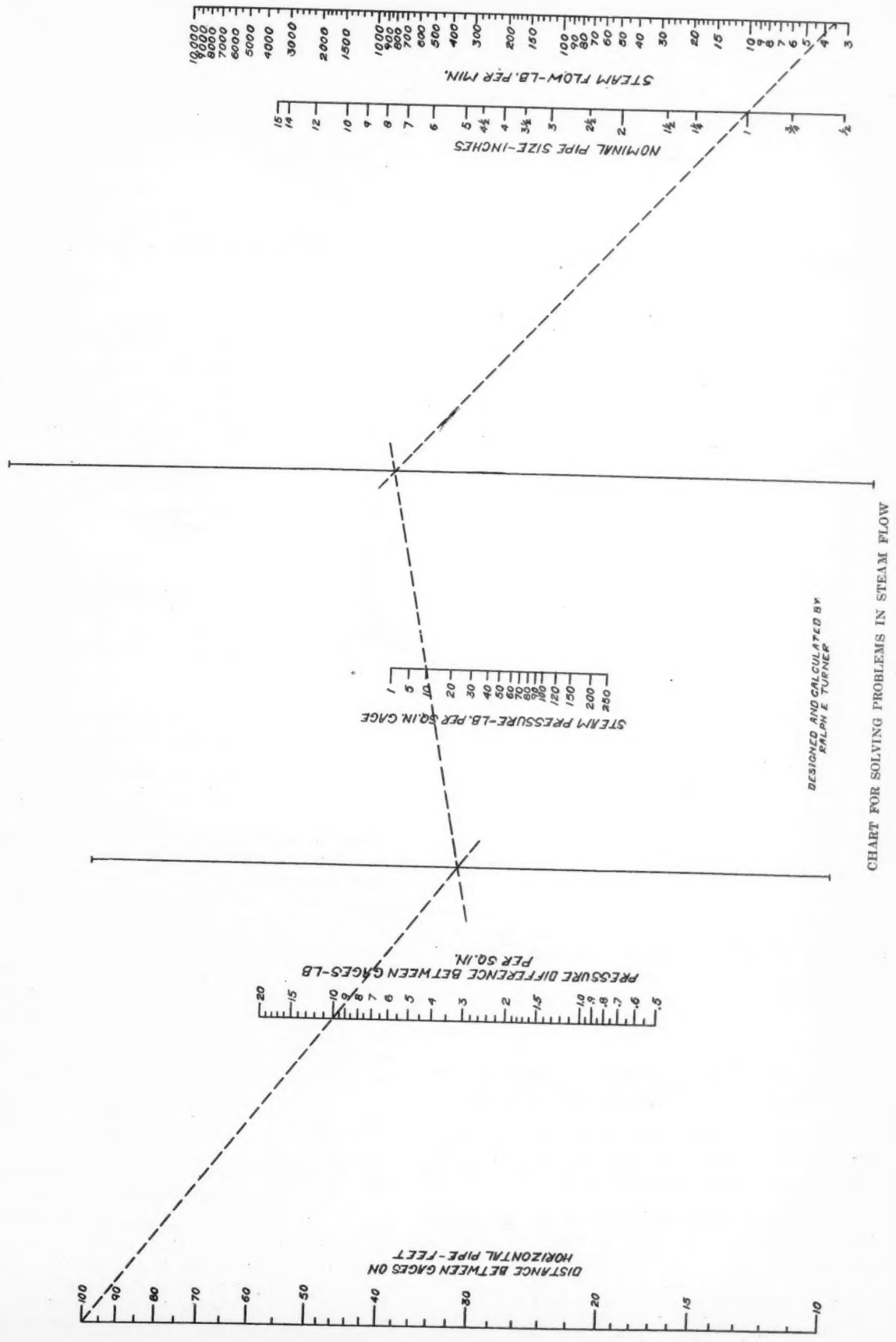
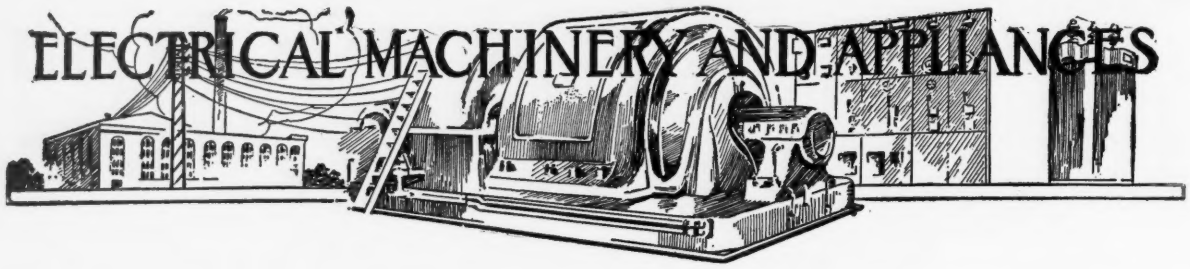

STEAM FLOW-LB. PER MIN.
NOMINAL PIPE SIZE-INCHES
STEAM PRESSURE-LB. PER SQ.IN. GAGE
PRESSURE DIFFERENCE BETWEEN GAGES-LB PER SQ.IN.
DISTANCE BETWEEN GAGES ON HORIZONTAL PIPE-FEET
DESIGNED AND CALCULATED BY RALPH E TURNER

CHART FOR SOLVING PROBLEMS IN STEAM FLOW



Construction of Industrial Electrical Distribution Systems---I

A Discussion of Current Practice: Overhead and Underground Systems. By V. E. Johnson

An industrial distributor system is made up of parts which may be tabulated as follows:

Outside System—
- Overhead;
- Underground.

Inside System—
- Open wiring;
- Concealed wiring;
- Conduit wiring.

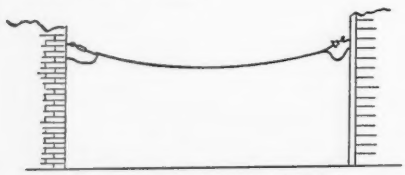
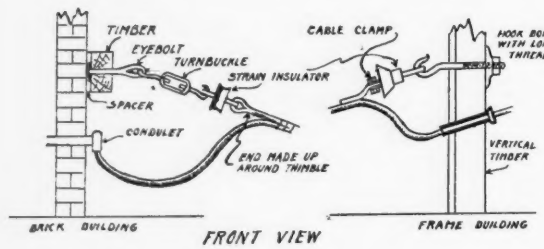


FIG. 1. ONE SPAN BETWEEN BUILDINGS



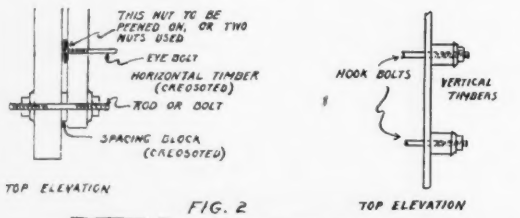


FIG. 2

FIG. 1. ONE SPAN BETWEEN TWO BUILDINGS

FIG. 2. DETAILS OF CONSTRUCTION SHOWN IN FIG. 1.

The simplest overhead construction in an industrial plant would be that of one span connecting two buildings. Figure 1 shows schematically how this would be constructed.

In Fig. 2 are shown the details of the dead ending. In this construction but little hardware and porcelain are used, as only strain insulators, clamps and turnbuckles are required. In Fig. 3 are shown in detail, strain insulators suitable for use, as in Fig. 2.

In the construction of the above span, perhaps the simplest method would be to lay the cable out on the ground between the two buildings and (after making proper allowance for the sag) making up the spans complete, and then hooking them in place. If the conductor used is light, it could be pulled into place with a cable clamp ("come along") and "made up" in the air. This would somewhat simplify the matter of securing equal sag in all of the wires, particularly if no convenient place for "ground" measuring were available.

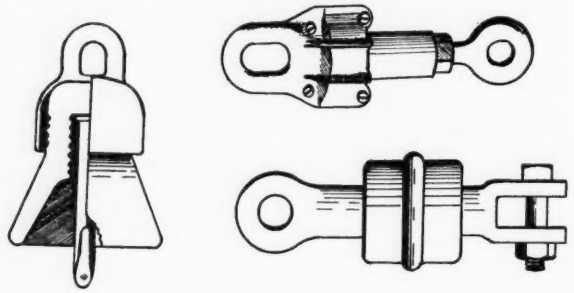


FIG. 3. TYPES OF STRAIN INSULATORS FOR USE IN CONSTRUCTION SHOWN IN FIG. 1

When the distance becomes too great for single span construction, poles must be used. In large plants the problem becomes similar to pole line construction for city distribution, except that there would be no question of tree trimming or securing of right-of-way; the line would ordinarily be entirely on the factory grounds.

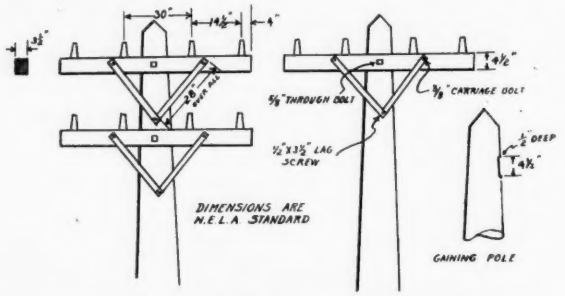


FIG. 4. TYPE OF SINGLE AND DOUBLE ARM POLE TOP CONSTRUCTION

The location of the line is determined by local conditions; care should be taken that no poles are set in places where they will be in the way of any of the manufacturing processes. The height of the poles is

also to some extent determined by this consideration—the wires must not interfere with the movement of apparatus about the yards. The shortest pole that will meet the above-mentioned requirements will in general be satisfactory, but it would hardly be advisable to have the wires less than 15 ft. from the ground at the lowest part of the span. With a spacing of 100 ft. this would give the following figures: Proper sag at 90 deg. F. (hot summer weather) for 100 ft. spacing is 24 in. On level ground, then, the wire on the cross arm would be 15 + 2 ft. = 17 ft. from the base of the pole. Allowing 6 in. from the wire to the top of the "roof" on the pole and 5 ft. for ground depth, the actual necessary length becomes 17 + ½ + 5 ft. = 22½ ft. The nearest commercial size is 25 ft. and this would be used. Naturally,

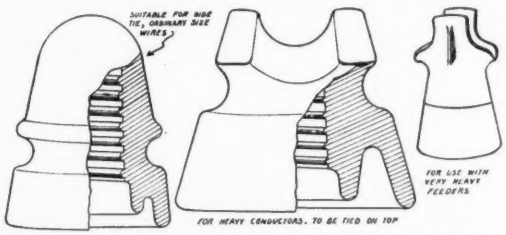


FIG. 5. INSULATORS SUITABLE FOR POLE WORK ILLUSTRATED IN FIG. 4

the topography of the country would have to be considered in determining these sizes. The weight of the line would determine the diameter of the poles used. The pole cost in an industrial distribution system is, however, usually such a small proportion of the total investment that the additional cost of the heavier poles need hardly be considered.

In Fig. 4 are shown the details of a 1-arm and a 2-arm pole top while Fig. 5 shows porcelain insulators adapted for this type of work. Glass insulators could be installed but the greater reliability of the porcelain makes its use more desirable.

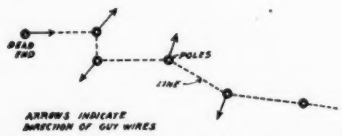


FIG. 6. SCHEMATIC ILLUSTRATION OF GUY WIRE APPLICATION

In order to make a "stiff" pole line, it must be properly braced. Figures 6 and 8 show the schematic location and the details of construction of common guys, while Fig. 7 shows how the line should be braced to relieve the poles from the unbalanced pull of a long span, such as may often be found necessary. Head guys or line guys should also be installed about every ½ mile on straight runs.

There are on the market today a number of patented anchors to take the place of the "dead man" shown in Fig. 8 and which have the great advantage that they can be installed by merely "screwing" them into the ground, no digging being necessary.

Setting Poles

THERE ARE two ordinary schemes of setting poles, namely the "pike pole" method and the "gin pole" method. The latter would hardly be justified unless a great number of poles were to be set.

The pike pole method is described briefly herewith.

The post hole having been dug to the depth indicated in the table below, and of a diameter sufficient to permit use of the tamping bars when filling, a plank 10 or 12 in. wide is placed in it and allowed to project over the ground about 2 ft. This plank provides a smooth surface for the butt of the pole to slide over

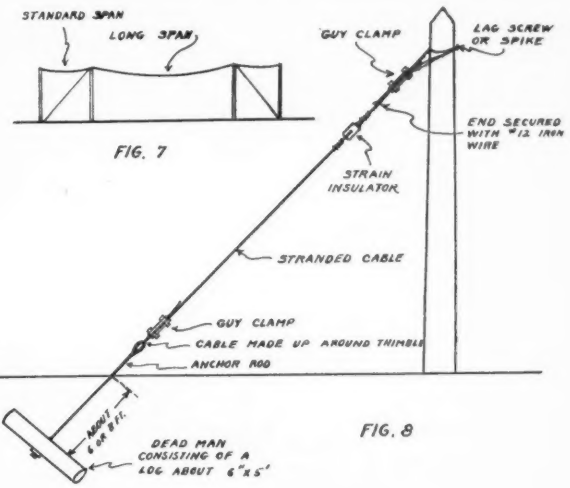


FIG 9

FIG. 10

FIG. 7. SHOWING HOW GUYS MAY BE EMPLOYED

FIG. 8. DETAILS OF GUY LINE CONSTRUCTION

FIG. 9. SHOWING METHOD OF INSERTING STRAIN INSULATOR INTO GUY

FIG. 10. A THREE-BOLT GUY CLAMP

during the process of erection. The pole, with the cross arms bolted to it and the insulators screwed in place, is laid with its end butting against this plank. It is then raised by hand as high as possible and rested on some support, until the pikes can be gotten into place, after which the lifting process is continued until the pole drops into place. Figure 11 shows, roughly, this method, and some of the tools used.

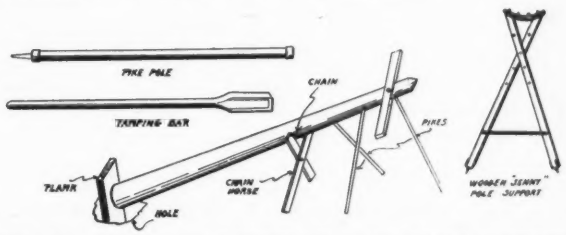


FIG. 11. METHOD OF RAISING POLE AND TOOLS EMPLOYED

After the pole is in the hole it should be "plumbed," that is, set vertically and held in this position by means of the pikes (their butts forced against the ground) while the earth is thoroughly tamped back. The surplus dirt should be piled and tamped around the pole to form a "rain shed."

DEPTH OF POST HOLES

Length of Pole	Depth, Straight Lines	Curves
Up to 30 ft.	5½ ft.	6½ ft.
30-40 ft.	6 ft.	6½ ft.
45 ft.	6½ ft.	7 ft.
50 ft.	7 ft.	7½ ft.

This table is based on good soil conditions. If soil is poor, poles must be set deeper, reinforced with concrete, or set in barrels filled with stone or gravel.

FIG. 12

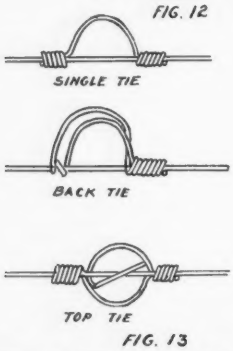


FIG. 13

FIG. 12. ECCENTRIC CLAMP OR SO-CALLED "COME-ALONG"
FIG. 13. METHODS OF TYING INSULATORS

After the poles have all been set, the wire (which should be triple-braid weatherproof) should be strung. This is done by taking the end of the wire from the coil and passing it over the cross arms, pulling it tight and then tying it to the insulators by means of "tie wires." The table below gives the permissible sag on weatherproof wire, triple-braid, 34,000 lb. tensile strength, based on a factor of safety of 4 and a minimum temperature of — 20 deg. F.

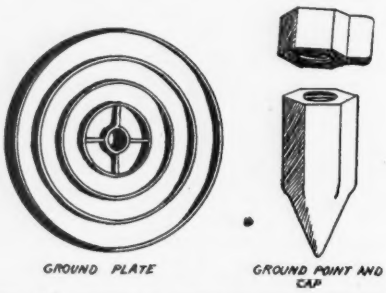


FIG. 14. TYPICAL GROUND CONNECTORS

PROPER SAG OF WIRE

Span	—Deflection at Various Temperatures— 30 deg.	50 deg.	70 deg.	90 deg.
50 ft.	8 in.	9 in.	11 in.	12 in.
80 ft.	13 in.	15 in.	17 in.	19 in.
100 ft.	16 in.	19 in.	21 in.	24 in.
140 ft.	22 in.	26 in.	30 in.	33 in.
180 ft.	29 in.	34 in.	39 in.	43 in.

(Above is a portion of a table given in the American Electricians' Handbook.)

In passing the wires over the cross arms a "hand line" is used. If they are not too heavy, several can be pulled at once if care is taken to avoid twisting and tangling. The wires are tightened by means of a block and tackle and a pair of cable grips or "come alongs" such as that shown in Fig. 12.

Tying should be done with wires the same size and insulation as the line except that for No. 1 and larger the tie should be No. 2 and should be "back tied" instead of "single tied," as illustrated in Fig. 13. Heavy cable lying on top of the insulator should be secured by means of patented cable clamps or else tied as shown. In going around a corner, the wire should be carried on the outside of the curve so that the tension will be against the porcelain. This is true also for top ground insulators—which should be "side tied" under such conditions.

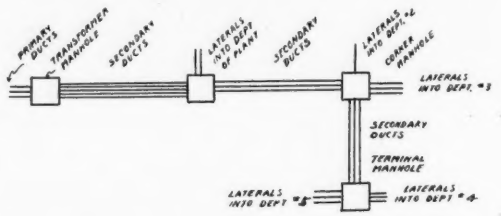


FIG. 15. ILLUSTRATING ESSENTIAL PARTS OF UNDERGROUND SYSTEM

GROUND CONNECTIONS

LIGHTNING ARRESTERS and other apparatus requiring a ground connection should be carefully installed. The ground wire should be protected by a molding, so that even if a high-voltage existed between it and the ground, nobody could be injured. The ground plate may consist of various devices, two of which are shown in Fig. 14.

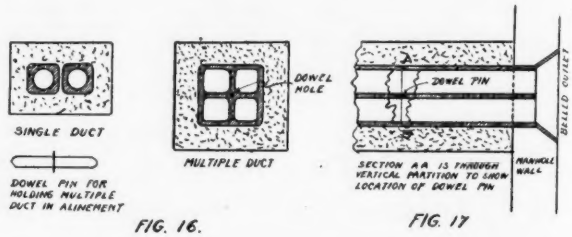

SINGLE DUCT
DOWEL PIN FOR HOLDING MULTIPLE DUCT IN ALINEMENT
DOWEL HOLE
MULTIPLE DUCT
DOWEL PIN
SECTION A-A IS THROUGH VERTICAL PARTITION TO SHOW LOCATION OF DOWEL PIN
MANHOLE WALL
BELLED OUTLET

FIG. 16. FIG. 17

FIG. 16. SECTIONS OF SINGLE AND MULTIPLE DUCT LAID IN CONCRETE
FIG. 17. LONGITUDINAL SECTION OF DUCT ENTERING MANHOLE

The cast-iron plate which is buried in the ground has a threaded hole in its center for connection purposes. The ground point and cap are screwed on the opposite ends of a ¾-in. pipe which is then driven into the ground. The cap has a lug for attaching the ground wire. Outside switching apparatus or any devices which require manipulation should have a platform built under them for the sake of convenience and safety. If possible, lights should be provided near these; it would be advisable to have these on an independent circuit so that in case of a night fire it would be possible to work rapidly even though the regular circuits were cut off.

Underground Systems

The underground position of an industrial distribution system consists of the following parts: Duct runs, the main lines of the system; manholes, the junction points; laterals, the side tracks.

Figure 15 illustrates these parts.

The most common material for ducts is vitrified clay, although of recent years impregnated fiber has become popular. Vitrified clay ducts are made in single and multiple forms, the former being more desirable from the standpoint of reliability; the staggered joints possible with it isolate any arc or flash and so reduce the resultant damage to a minimum. The impregnated fiber ducts resemble pipe in form and are made with either slip or screw joints.

In laying duct (single or multiple) the trench is tamped hard, and a 3-in. slab of concrete laid over it as a foundation. This should slope towards the manholes—about 1 ft. per 100 ft.—to prevent water accumulations. On this concrete slab is laid the tile (using cement mortar), great care being taken to keep it in alinement. Single tile is usually alined by means of wooden mandrels inserted into them and passing through several lengths (these being moved along as the work progresses), while multiple duct is held in line with dowel pins which fit into holes molded in the end of each piece. Each joint is covered with a piece of burlap or with a piece of oiled or tarred paper held in place with a trowelful of mortar.

After the mortar has set, the entire run is covered with concrete, 3 in. or more at the sides, and of a top thickness sufficient to take care of the loads imposed on it from above. There should be at least 2 ft. of earth between the top of the cement and the surface of the ground unless the run is protected by some structure such as a bridge or tramway.

In Fig. 16 are shown cross-sections of single and multiple duct laid in cement. Figure 17 shows a longitudinal section of a duct run entering a manhole.

Safety Features in High Tension Stations*

The Simplest Arrangement of a Station is Also the Safest Arrangement. By M. M. Samuels

On high tension work it is not necessary to make any distinction between hazard to life and limb and hazard to property. It would require considerable stretching of the imagination to conceive a case where the addition of hazards to the operator would make the apparatus or surrounding property safer. It may therefore be stated as a first postulate that on high tension work safety to life and limb and safety to property are identical.

At a time when industry is struggling to recuperate and regain its old foothold, it would be folly to suggest the introduction of safety means in such numbers and in such manner as would make high tension installations unnecessarily expensive because this might in some cases make high tension development so expensive that they could not be put through at all. Even though this would mean absolute safety, I do not think that safety engineers desire to go that far. However, as it is well known that the simplest arrangement of stations is the most economical, so it may be stated as a second postulate that the simplest arrangement of stations is also the safest arrangement. The introduction of safety features, therefore, if reasonably done by skilled engineers, will generally not require any great additional expenditures. In spite of the fact that the best design of a station from all points of view is the simplest design, there is no doubt that a great many of the existing power stations and substations in this country as well as abroad are unnecessarily complicated, due in all probability to lack of skill on the part of the designer. A simple design when completed appears as though it could not be any different, as though it were the only possible and self-evident way of arranging the equipment in the station. As a matter of fact, however, the simplest design is the most difficult and requires the greatest skill, since, in very few cases, a designer will think in the beginning of the simplest way. It is peculiar that to most designers the most complicated way offers itself first, and also that complicated designs are generally appreciated much more than simple designs. The remark is often heard: "This is a very complicated station; it must have taken a great deal of engineering skill to design it," whereas, the fact of the matter is that the lack of engineering skill is just what made it complicated. It is often discouraging to a designing engineer who is attempting to bring out simple designs and meets with so much lack of appreciation of the simplicity of the designs and it is often a temptation to an engineer who is not independent enough in his ideas to make a design complicated in order to obtain more recognition.

There is little to be said in regard to safety features on high tension apparatus, such as generators, transformers, etc. The necessary safety features on large generators are generally taken care of by manufacturers as a matter of course. The only thing that may be mentioned with reference to generators is that the air ducts should be laid out in such a way as to avoid fire hazards. "Ventilation but no draft" is not only a good sanitary rule, but holds equally well for all indoor high tension rooms.

Transformers

Transformers have not been in the habit of late of blowing up. One very seldom hears of transformer explosions and the fear which people generally still have of high tension transformers is mostly of a mythical nature and therefore highly exaggerated. Live parts of large transformers are always out of reach and cannot possibly cause any hazard. Some authorities require a sewer connection with quickly operating valve from each transformer. This would be a wise precaution if an operator could be found who would be willing to go and operate this valve, when a fire occurs inside of a transformer.

The old style thermometers, which used to be on top of the transformer casing and were the cause of hazards

* Abstract of paper delivered before the American Association of Safety Engineers.

to operators who had to climb ladders in order to read temperatures, have been eliminated, and dial type thermometers, mounted so that they can be read from the ground, are now in general use. In spite of the fact that there are still some engineers who are of the opinion that transformers should be housed, it may be said, without fear of contradiction, that the majority of experienced engineers will not even consider the placing of transformers inside of buildings, which may be proved by the fact that practically all transformers now manufactured by all manufacturers are of the outdoor type, even when they are housed. There is no argument whatever any more for placing transformers inside of buildings. To my mind the future type of a large transformer substation will consist principally of an underground concrete tank for each phase, located at a considerable distance from the power house and containing in the same oil the transformer, high tension oil switch, low tension oil switch, current transformers and potential transformers, thus saving something like 12 high tension bushings, per circuit, which mean 12 sources of trouble.

High tension lightning arresters should always be surrounded with wire mesh fencing, and all arresters which have charging mechanisms or transfer device mechanisms should have those mechanisms on the outside of the fence so that they can be operated without any possibility of an operator accidentally coming in contact with a tank which, of course, is energized during the period of charging.

From the mere point of view of safety it is no doubt preferable to use one of the newer types of arresters which require no charging, such as the oxide film arrester or the Bennett-Surge arrester.

Bus Structures and Disconnects

Bus structures in power houses should be simple, and, if possible, the oil circuit breakers, busses and disconnecting switches should be absolutely separated from each other by means of barriers containing no holes whatever. I can see no reason for designing a bus structure at all if half of it is left out by all kinds of openings, which are required by unnecessarily complicated layouts. It is always possible by proper designing to make a bus structure simple. The introduction of mechanically operated disconnecting switches as against the hook switches commonly used, will eliminate a great deal of danger without making the design of the structure any more complicated. It should be the tendency of safety engineers to eliminate hook switches altogether, since they have always been a source of trouble to operators and to property. Unfortunately, there are not many types of mechanically operated disconnecting switches on the market as yet which may be called satisfactory designs, but with an increased demand for this type of disconnecting switches, there is no doubt that new designs will be brought out which will be more suitable for the purpose than those on the market at present.

In some cases where hook disconnecting switches were found to cause trouble, it was attempted to remedy this by interlocking the doors of the disconnecting switch compartments with the oil switch mechanisms so that the doors could not be opened unless the oil switch was open. This, however, was found to give additional trouble, since, in some cases, the mechanisms which are bound to be very complicated, did not function properly and it was necessary to break the doors when the disconnecting switches had to be opened quickly in order to clear a circuit.

In cases where great rupturing capacities are not required, truck type switchboards are to be highly recommended. This type of switchboard has been developed for voltages up to 15,000. It is compact, requiring very little space and absolutely safe, but still somewhat too expensive. When truck switchboards become more popular they will, no doubt, also become cheaper.

In the majority of power houses, the trip coils of all oil circuit breakers are generally in series with the one bell alarm relay when tripping. If this one bell alarm relay should happen to be out of commission, none of the oil circuit breakers in the station would trip under overload or short circuit and would thus cause a great deal of damage. In order to eliminate this danger some up-to-date stations are using little tripping relays in each circuit, thus making the tripping circuit for each oil circuit breaker independent.

Use of Signal Lamps

Signal lamps should be installed on all high tension apparatus, such as transformers, oil switches, regulators, etc., to indicate whether or not they are alive. When using signal lights, the principle should not be lost sight of that one lamp is not sufficient for indicating whether or not a circuit is alive, because it is possible for this one lamp to be burned out. Both red and green lamps must be used. The small additional expenditure involved in providing such red and green lamps will often mean the saving of a good many dollars and perhaps often a saving in human life. The following case may serve as an illustration:

A set of 44,000-v. current transformers was installed on one common foundation with an oil switch. The circuit ran as follows: From high tension bus to disconnecting switch to oil switch to current transformer and out to the line. It was necessary for an operator to repair the current transformer. He promptly opened the oil switch, thus killing the current transformers, went up on the foundation, repaired the current transformer without any trouble, but when attempting to descend, he accidentally reached over to that terminal of the oil switch which was connected to the disconnecting switch, and since he had forgotten to open the disconnecting switch, the terminal was alive and killed him. If red and green lamps had been installed on the oil switch, that operator would not have attempted to do any work on any part of it with the red lamp on. In order to make it possible to use these red and green lamps, it is, of course, necessary to use mechanically operated disconnecting switches, since it is not possible to install auxiliary switches on hook disconnecting switches.

When using electrically operated oil circuit breakers, it would be possible for an operator at the switchboard to close an oil circuit breaker upon which somebody may be working and thus injure him. In order to avoid this possibility, we are now using push button switches in the closing circuit of the oil switch. Such a push button switch is located near the oil switch, and, if a man wants to work on an oil switch, he opens this push button, thus disconnecting the control circuit and making it impos-

sible for the operator to close the oil circuit breaker from the switchboard.

All high tension stations should be properly illuminated, and the best and easiest way to illuminate a high tension station, especially when poletop apparatus are used, is by means of flood light. There may, however, be some cases where it would be necessary to install fixtures in addition to the flood light, as, for instance, a case when transformers are arranged in two rows, in which case it would be very difficult to illuminate the isle between the two rows of transformers by means of flood light.

Some Effects of Vibration on Electrical Machinery

OPEN CIRCUITS, SHORT CIRCUITS, BURNOUTS, CHATTERING BRUSHES, HOT BEARINGS — ALL HAVE BEEN CAUSED BY VIBRATION. BY K. RANKIN

IN the June 1, 1921, issue of Power Plant Engineering, the writer briefly discussed how vibration of foundations and noises may often be prevented or lessened. In the following some of the effects of vibration on electrical machinery are discussed; and where troubles resulting from it may be expected to be found.

Vibration of electrical machinery may be due to internal or external causes or both, the one contributing to the other with a cumulative effect. The effects of vibration may be divided into two classes, namely those that exist only while vibration exists; and those that persist even after the vibration has been stopped.

Among the more common causes of vibration are unbalanced rotor, bent shaft, improper foundations, incorrect alinement, loose fastenings, excessive and fluctuating loads, vibration of superstructures. Many of these causes are cumulative. Many machines show less vibration at no load than at heavy load and vice versa; sometimes vibration occurs only at certain loads, others, again, only during load changes. The effects of vibration are also different with alternating current than with direct current apparatus and the latter generally suffer more than the former.

DIRECT CURRENT APPARATUS

IN DIRECT CURRENT apparatus vibration causes loose connections in the field circuit, breakages due to crystallization, open circuits and short circuits between turns and layers as the result of erosion and abrasion. These may necessitate additional ampere-turns to maintain voltage or speed, overheating, erratic voltage and speed variation and poor regulation. Grounds frequently result from vibration and insulation deterioration.

The foregoing effects result gradually. More quickly seen are commutation troubles. Brushes chatter, causing sparking which in turn causes poor commutation, overheating of commutator segments and brushes and hastened deterioration of brushes. Moving the brushes backward or forward, as the case may be, affects the armature reaction and so introduces another factor contributing to commutation difficulties on changing load. Excessive heating of the brushes changes their characteristics and contact resistance between brushes and commutator. With cheap oil-boiled brushes of the abrasive type, high temperature causes gumming, sticking brushes, increased sparking and rough commutator.

Ring fire, carbon dust, flat spots, pigtails burnt off and melted solder at the commutator segments result from vibration and are cumulative in interfering with commutation. A bent shaft in setting up vibrations also causes an unequal air gap which may cause overheating of the equalizer rings or taps, glowing or brushes and flat bars on the commutator. High mica is also a cause as well as an effect of bad commutation.

A bent shaft usually becomes more bent until the armature may foul the pole faces, thereby forming still another source of heating; lubricating oil may be thrown out, to eat into the mica and insulation in proximity. Oil is the arch enemy of mica. By making armature vents sticky, oil accelerates the clogging of these ducts by dirt and dust and so is also a factor contributing to overheating and reduced machine capacity. Dust collections and oil increase the fire hazard of a machine.

Many machines have speeded and destroyed themselves because of an open field circuit caused by continual vibration and eventual failure of the connection or fracture of the conductor. Soldered field wires sometimes melt because of overheating and so cause dangerous speeds. Field coil connections may be soldered; it lowers the contact resistance. But dependence should not be placed upon the solder for physical contact.

ALTERNATING CURRENT MACHINES

ALTERNATING CURRENT machines may, of course, be rotating or stationary. With stationary machines, vibration is comparatively small and may be due to superimposed vibrations transmitted to the stationary machine or may be internal, as due to magnetization. Loose contacts, chafed insulation, grounds and local current may result from the latter and, in turn, erratic voltage, overloading, excessive heating and sludged oil.

With the rotating type of machine the troubles of the commutator are absent, except when there is a direct-connected exciter in which case it may suffer in the same way that direct-current suffers under vibration. The capacity of the exciter, in the case of the alternating current generator, is so small compared with the alternating current unit that the vibration of the latter rather obliterates that of the former by absorbing the vibrations that would be set up by the exciter.

With the alternating current generator proper, however, vibration may cause trouble with current collection. This comes about from loose connections, sticking and chattering brushes, high contact resistance between brushes and collector rings. This becomes of greater importance at heavy loads and low power-factors because of the greater number of ampere-turns required to overcome the counter electromotive force set up by the armature at such times.

Grounded field and short-circuited turns are common with attendant difficulties because of the greater exciting current required for a given terminal voltage. Vibration of the entire machine may cause loose conductors in the armature (stationary on all except the smallest machines), abrasion of the insulation and final dielectric failure. The huge magnetic stresses set up on severe short circuits are a form of vibration that has wrecked machines. Not infrequently, however, the damage done during a severe short circuit does not make itself felt

until later when the insulation finally fails from abrasion or puncture during a surge.

Another result of vibration encountered with turbo-generators is that the emergency steam valve drops closed accidentally. A machine then shuts down and loses its load. The accumulation of scale, sludge and dirt on turbine blades and stripped blades are, theoretically, causes of vibration because they set up unbalanced conditions in the turbine rotor. Uneven expansion of a rotor due to rapid and uneven heating is another and transient form of unbalancing.

The vibration that occurs to apparatus subject to extremely severe service, as motors in steel mills, on gantry cranes and skip hoists, is responsible for the heavy maintenance costs and the rapid failure of motors. The cast-iron grids of resistance units, unless properly safe-guarded, break under the repeated movement, causing improper motor operation and interrupted service. Relays do not close so that motors fail to start or in other ways fail to function properly and the relay contacts are due to the rapid opening and closing or intermittent contact.

It is economy to eliminate every remedial cause of vibration. To do so is to lessen shut-downs, lengthen the life of apparatus, improve performance in general and make for more uniform and reliable service.

Meters for Various Voltages and Loads

By Dan C. Hoffmann

OFTEN it is necessary in general testing work to record the number of kilowatt-hours consumed by a temporary but unusually heavy load, and when the proper capacity meters or instrument transformers are not on hand, the desired result may be obtained by connecting smaller meters that are on hand so that the combination will carry and record the load without overloading the meters or sacrificing the accuracy of the test. There may be various different loads and pressures to be measured and several important cases will be considered.

Suppose for instance, that a load taking 80 amp. at a pressure 110 v. is to be recorded, and an 80-amp. meter cannot be quickly or easily obtained. The power may then be measured by connecting up two 40 amp., or a 60 and 20-amp. meter in "multiple," as shown in Fig. 1. The current coils are in multiple with each other, but in series with the load, and the potential coils are in multiple with each other across the line. The 80 amp. will now divide between the two current coils in proportion to the capacities of the meters, therefore each meter will carry and record its share of the load. The total number of kilowatt-hours consumed will be the sum of the number of kilowatt-hours recorded by each meter separately. As a precaution it would be well to try this connection out on a partial load to make certain that the load divides as desired.

Another case arises when the pressure is 220 v. instead of 110. Supposing that two 80-amp., 110-v. meters are on hand, the potential coils may be connected in series across the line, and the current coils in series with each other and the load, as in Fig. 2. Again the total power will be the sum of the two readings.

Another way of getting at the same results would be to use a standard 40-amp., 220-v. polyphase meter, and make the connections as shown in Fig. 3. The potential coils are in multiple across the line, and the current coils in multiple with each other but in series with the load. The total power will then be recorded directly on the meter dials. Care should be taken that the meters run in the proper directions.

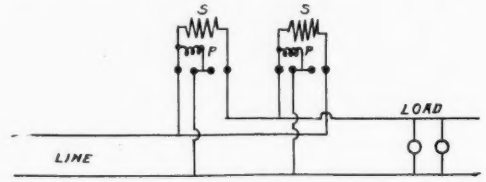


FIG. 1

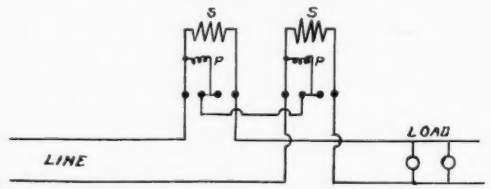


FIG. 2

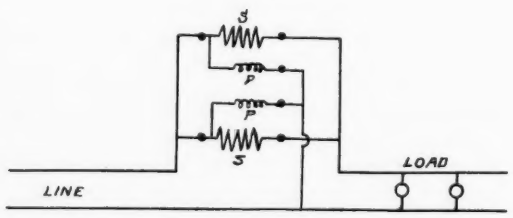


FIG. 3

FIG. 1. METER CONNECTIONS TO BE USED WHEN CURRENT IS ABOVE RATED CAPACITY OF EITHER METER
FIG. 2. CONNECTIONS FOR 110-V. METERS ON 220-V. LINE
FIG. 3. USE OF POLYPHASE METER ON SINGLE-PHASE CIRCUIT

When using this combination of meters, the best results will be obtained if the meters are all of the same make and type. This system applies either to direct current or alternating current, but will be more appreciated in direct current work, as no instrument transformers can be used.

Electrical Manufactures

FIGURES from the Bureau of Census show that the value of electrical machinery and apparatus manufactured has increased from $359,432,000 in 1914 to $1,014,373,000 in 1919.

One surprising feature is that small dynamos and self-contained lighting outfits, both of which run over $29,000,000, were more than double d.c. and a.c. generators, each of which were over $13,000,000.

The largest item was motors, nearly $117,000,000, and the next in size, batteries, $92,500,000, followed by wire and cables, $84,000,000; incandescent lamps, $59,372,000; household appliances, $55,000,000; telephones, $46,340,000; ignition apparatus, $47,400,000; transformers, $31,700,000; and rheostats, $21,542,000. The balance is made up of classifications running less than $20,000,000 each.

Trouble Hunting—III

By John Pierce

SINCE my last letter to Power Plant Engineering, I have been into the "wild and woolly parts of Mexico, and I have seen trouble a-plenty. I have seen good Americans shot down, and bad Mexicans following suit; the only difference being that the Americans were buried, while the Mexicans were thrown in the river to float away. But this latest experience in "trouble" will have to wait until the story has reached that point. In my last article, I had just reached the point where I was to enter upon my new duties as assistant, and later on, as master mechanic. Naturally I was shown over the place and all parts of the property pertaining to the mechanical department were visited. I was surprised; surprised for many reasons. One was that I had gone into Mexico thinking I'd find old worn-out and dilapidated machinery, sent there and put into service after it would no longer be of use in the States, and in place of this I found modern, up-to-date engines, blowers, generators and other mechanical appliances of the very best. The greatest surprise was to find these modern machines running quietly and smoothly and being "kept up" in a way that would be a credit to the best maintained and operated plants found anywhere in the United States, or, for that matter, any place in the world. Of course I will have to admit that it was so, simply because the heads of each department were Americans, and not the native sons of toil who were furnishing the brains.

Another surprise was to discover the multitude of duties pertaining to my department. First came the machine shop, which was equipped with three fine lathes, a shaper, a milling machine, several drill presses, grinders, emery stands, planers, bolt machines, pipe machines, hydraulic presses, and other small appliances for many purposes. We went next to the boiler shop, where we found the necessary outfits to make boilers from the ground up. In this department were made the jackets, canals, spouts, noses and gutters, all of which were used on the smelting furnaces proper, as well as the machinery to make and repair the charge cars, wheelbarrows, slag and dump cars. From the boiler shops I was taken to the blacksmith shops, where I was introduced to my smiths, their helpers and apprentices. I took count of the men in this department, and found I had ten forges, and two large steam hammers, all operated by Mexicans.

At the time it looked as if I had enough smiths to supply work for a dozen places, but I later found that I needed more.

From the smithy I was taken to the brass and iron foundry, where we made castings of every description, from wheelbarrow wheels to locomotive cylinders. It is true that the two foundries were crude homemade affairs and were, perhaps, not as handily arranged as some which one finds at home in the states, but there had been no appropriation made for foundries, and they were made of scrap material, costing the company nothing to build except a little native labor. They were dug out of the ground and had no cupola, the ore being melted by a blast from below, the melted metals running into a basin whence they were dipped by a crane handling enormous ladles, and these were swung over the molds and poured. The brass foundry was simply a pit dug into the earth and lined with fire brick, into which crucibles were set; a blast of air applied to the coke beneath, and the brass thus smelted.

Later on, I made one of quite a different type, looking like a dutch oven and in which I placed four oil burners of the Tate Jones type. I charged my furnace with about the amount of metal I wished to pour and with plenty of coke. Of course, I allowed some considerable excess of metal, because of there being always some loss. I swung my molds into place beneath the "tap" and would tap my furnace as is tapped any other furnace, pouring my metal directly into the mould and then plugging the furnace again until a new mould could be swung into position. The only trouble with this furnace was that I did not so construct it that I could charge and recharge at will; however, it was built only as a temporary arrangement. Later, using old sheets from discarded jackets, I built a small modern cupola such as is found in any small foundry in the country, using the cross-sectioned drawing of a modern furnace as my "points" for the construction.

From the foundry, where we have lingered that I might brag a little, we went to the "yards." I found that we had something over two miles of narrow gage track, used by the seven electric locomotives (which were under the mechanical head) and about the same of "standard gage" track, used by the company's locomotives and trains. It might be well to explain at this time that in Mexico the railroads are owned by certain various companies, although they were seized by the Mexican Government several years ago, and have been operated by that Government since then "and to hell with the owners." But the practice has continued and still continues, of leasing the right to any person or company to use the rails and run privately-owned trains and engines over the rails. Thus it will be understood when I speak of our "locomotives," as the company by which I was employed owned and operated some 50 engines and hundreds of cars. We had our locomotive pits and kept in repair the engines directly stationed at this point, as well as those arriving there from other divisions. Sometimes, as I found later on, we were obliged to repair, *free,* the engines operated by the Government and used in their military trains. Of course we received their promises to pay, but a promise given in Mexico is only a joke, and should be taken as such in good spirit.

From the yards we went to the elevators of which there were three double electrics and four hydraulics. These were used to raise the "ore," or "change" cars from the floor where they were loaded, to the upper floor where they were run by hand and dumped into the furnaces, returning to the lower floor to be refilled.

From here we visited the "sampling mill" which contained a number of rolls and crushers, and a world of shafting, belting, etc.

Next we came to the carpenter shop where all the furniture for the colony was made and repaired, while in various departments of this building were housed the housebuilding carpenters, and the plant carpenters, as well as the furniture men. Here we found lathes, saws, planes, and all sorts of wood-working machines. One department was solely to make any miscellaneous thing which anyone in the colony might devise, and the first

thing that I was asked to make in this department was a boat.

We then visited the painters' and varnishers' department and from there the masons and bricklayers.

By this time I was beginning to feel that the job I'd take on was *some* job and I was wondering if there were any more places to see. I also began to wonder if your poor old Uncle John had not bitten off a little more than he could chew, he being along in life, and his teeth not the best in the world. But I said nothing —and looked as intelligent as was possible, which at the best is but poor, and followed my conductor about the place, coming soon to the electrical department; here I found a lot of motors which needed "fixin' " and needed it badly. This was the first point that I had reached where there seemed to be any delay in the work, and here I found as good men as the average; but the old "master" was not "up" on this kind of work, and here was first demonstrated to me clearly that while the Mexican may be taught to "ape" and *repeat* anything shown him, he simply *did not* have the brains to *think* out anything for himself. For instance if, in my machine shop I'd make a drawing—even a rough one—showing the shape and dimensions of anything in the world, my machinists could make it; but were I to tell one of them a certain thing was needed and, for example, removed the bolt needed from the machine where it belonged, so that they could not pattern after it, they had not the ingenuity to go ahead and figure out some means of replacing the removed bolt. They were like a good engine with no governor. Later on I will tell you how I "broke them in" and showed them the roots of electricity, explaining, to the best of my ability, the why and wherefore of it, and *why* it worked, rather along the lines it worked on, and this department, having a capable Mexican at its head, forged rapidly ahead.

We then visited the cooling towers and from there to the condenser plant. Everyone is familiar with jet condensers, so we found nothing different here from the ordinary American condensers. We stopped next at the pump station and of all the different sized pumping apparatus, and different types in the world, I think I found them here. And there were so many and the space so full that we went through the pump house by walking *over* the pumps, not between them. This, I think, was the worst place, by that I mean the most poorly designed place, I found in the entire works. Just outside this place was the boiler house, where oil was used as fuel. Here I began to feel in more familiar surroundings, and when I learned that we were evaporating only 8 lb. of water per pound of oil, I knew I could make *some* improvements here.

As I write these lines I feel silly, and as I thought about making the improvements on the evaporation at that place I felt sillier, for it came to me about a certain article I had written for "Practical Engineer" many, many moons ago, and which led to a controversy between myself and the dean of an agricultural college in Oklahoma. I had made many exhaustive tests on oil burning and evaporation, and as a result I found that I could evaporate *only* so much water at a certain consumption of oil, the dean maintaining that he had almost trebled the amount of water. I, like a fool, said there was no such animal, and it was a year later in going over my old report and test figures when I discovered an error in my figures which showed me I'd done as well as the dean but didn't know it. Dean, old dear, I take off my hat to you, even now, and make you an apology, which I've silently made these many times. I call myself again, as I often have before, a poor "damphool." If you read these lines, old chap, and will tell me where you are, I'll write you an even more humble apology.

But to get on. From the boiler house we passed into the ice plant, and from there to the power house. It was certainly a beautiful sight—those big old Nordberg compounds lined up, filling a building over 300 ft. long and every engine running like a watch. I could not help but admire the old man who was leading me through the place, and I believe I offered up a silent prayer that I might be capable of keeping those wonderful machines in as fine a condition as I was receiving them. By this time, you may be sure that I was feeling very much as if the job was entirely too big for me, and I felt very much like folding my tent and slipping quietly away.

From the power plant we went to the "blowers" and this was my first sight of the monstrous fans—I called them fans—which force air into the furnaces of the smelters.

Then we went over the colony where I found several neat bungalows under construction, and a new laboratory and assay office.

All the things we had visited in this journey were to be under my direct charge and I was tired and very much scared. But I stuck, and I'm glad I did. I start work in my next article, and while I accomplished nothing out of the way, did make a few *valuable* improvements, which I will write about later on.

Cutting Freight Rates on Coal

By J. B. Dillon

IF the Colorado state utilities commission can cut the freight rate on coal for a short haul, surely they can do so for a long haul.

The Colorado Springs Chamber of Commerce petitioned the commission to reduce the freight rate on coal, from Pikeview to Colorado Springs, a distance of 5.8 mi. and the following was the award: "It is necessary to the railroads themselves that freight rates on coal should be reasonable; coal has always been classed as a commodity that should take a low rate per ton per mile. The base rate in question, before the recent high cost of operation and the numerous recent increases in labor and material for something like a 5-mi. haul, was 25 cents. By a succession of continued increases the Federal Administration and the interstate commerce commission, together with the last increase of 35 per cent on all freight rates allowed by the commission, all rates have been tremendously increased, and in the opinion of the commission in the present instance, a rate of 67.5 cents has been produced, which is unreasonably high and is more than the service is worth."

The rate was cut to 50 cents and it is intimated that other cuts will follow. Certainly any other state utility commission has the same power as that of Colorado. Try it.

Power Plant Troubles

EVERYDAY WORRIES OF UNUSUAL TYPE SOLVED IN PRACTICAL MANNER. BY H. A. JAHNKE

FREQUENTLY we find an engineer who has much trouble with some apparatus under his charge which may be a broken or worn member of some equipment or some wrong adjustment in an engine pump, etc., which, perhaps, to some other engineer would be very simple to repair or adjust. No engineer should be ashamed to ask one of more experience for advice on the matter, as it may avoid much trouble and perhaps a shut-down of the plant, should the apparatus not be repaired immediately or the adjustment corrected.

Often an engineer tries to make a repair on some equipment and a few days later the same trouble appears again, then the same performance is repeated; in other words, the repair was only temporary, merely to keep the plant going. In a case of this kind the engineer is in trouble most of the time.

To show how true this is, I relate the following: A small slide valve engine was installed for driving a line shaft. A few months after this engine was in service, a leak appeared in the bonnet on the throttle valve of the engine. The body of the valve was cast iron, while the bonnet was of brass and screwed into the valve body.

The engineer tried to repair the leak by soldering that part of the bonnet where it leaked, but the repair would hold only a few days when the same performance was repeated. I had noticed this leak a number of times while visiting at the plant, but paid little attention to it until one day while there, I noticed that the bonnet was leaking worse than ever. Inquiring as to the cause, I was informed by the engineer that there was a sand hole in the body of the bonnet, as shown in Fig. 1, at A, about ⅛ in. in diameter, and this the engineer tried to stop with solder; but it seemed as if the steam would eat its way through the solder in a few days, when the soldering would be repeated again.

As it was near the noon hour, I suggested to the engineer that we remove the bonnet from the valve during the noon hour so I could examine the sand hole and perhaps suggest a better remedy than soldering. The steam was shut off on top of the boiler, then the bonnet was removed. After examining it, I stopped up the sand hole by drilling and tapping this for a ¼-in. brass pipe plug at that part of the bonnet which enters the valve body, as shown at B. After the bonnet was replaced and steam turned into the pipe, there was no sign of a leak.

In another instance, an engineer had trouble with a joint on his engine lubricator leaking continuously, but knew of no way to remedy the trouble.

Most sight feed lubricators that have a condensation chamber on top of the lubricator body also have a ¼-in. pipe running from the condensation chamber some distance above the engine throttle into the main steam pipe. On the average lubricator, this pipe is connected to the chamber with a ground joint union. It was this union that leaked badly and somewhat interfered with the proper working of the lubricator, but this man merely tried to stop the leak by screwing down on the union nut as hard as was possible, then, seeing that this did not prevent the leak, let it go at that, giving the matter no more attention.

One day he called my attention to the leak, saying that it was his intention to ask the boss for a new lubricator, then I suggested repairing the one he had by grinding in the joint. This was done, and after all parts were connected again and steam was turned into the pipe, there was no sign of a leak at the union joint.

GAGE FOR VALVE WHEEL

AT TIMES it is necessary only to crack or partly open a steam, water or air valve on an apparatus; it also is necessary to open the valve the same distance again after each closing. This, however, is not possible by guess-work; the valve is either opened too wide or not wide enough, hence the apparatus will not work as it should.

We have a valve in our plant which must be operated in this way. To do away with guess-work, we fastened

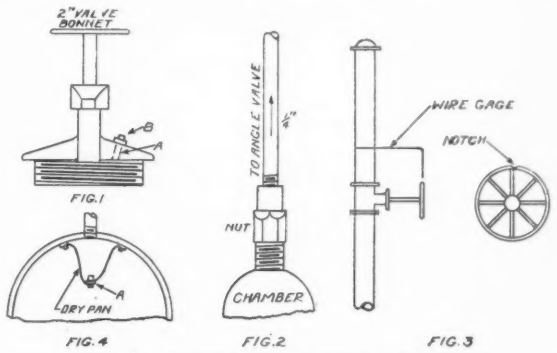


FIG. 1. VALVE BONNET WITH SAND HOLE
FIG. 2. LUBRICATOR UNION THAT GAVE TROUBLE
FIG. 3. VALVE WHEEL FITTED WITH GAGE
FIG. 4. LOCATION OF NUT ON DRY PAN THAT CAME OFF

a wire around the pipe next to the valve, as shown in Fig. 3. Then the valve was opened the required distance and a notch filed into the valve wheel to correspond with the point on the wire gage; with this arrangement there is no guess-work. We know that when the notch in the valve wheel is in line with the gage, the valve is set right.

WHY THE BLOWOFF VALVE LEAKED

SOME TIME ago I opened the blowoff valve to blow some of the dirty water out of the boiler. In closing the valve I found that I could not close it tight. It seemed as if there was a piece of scale under the disc; to remove this the valve had to be opened and closed a number of times. After the scale, or whatever it was, was removed, the valve kept on leaking a little. At the next boiler cleaning, when I examined the valve I found that the disc was cut badly and it seemed as if something harder than scale had been under the disc at the time when I could not close the valve after blowing some of the dirty water out of the boiler.

When making an interior examination of the boiler, I found what had caused the trouble. It will be noticed that the dry pan in our boiler under the steam nozzle

is jointed together in the center and held with bolts. I noticed that one of the nuts from these bolts had worked off, as shown in Fig. 4, at A, then it had found it way into the blowoff pipe and valve, cutting the disc. A new nut was placed on the bolt. To prevent this and the other nuts from coming off and causing trouble, I made a center punch mark on the bolt threads next to the nut.

Where the Oil Came From

In the power plant of a manufacturing concern, it was noticed for some time that more or less cylinder oil was accumulating in the boiler. Nobody seemed to know where this oil came from, as the water heater was of the closed type and no returns from the heating were returned into the boiler. This was a puzzle for some time, until the cause finally was found accidentally.

For lubricating the engine cylinder pumps and other steam using apparatus, a pressure tank system was used.

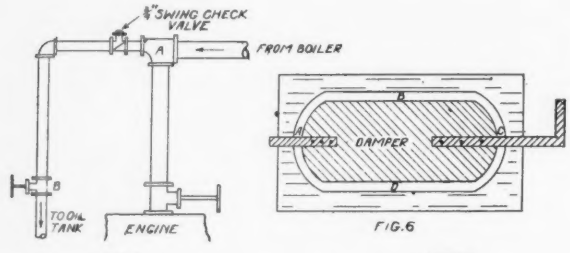


FIG. 5

FIG. 6

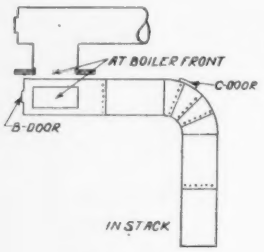


FIG. 7

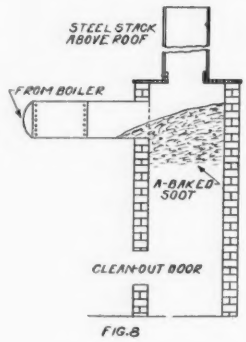


FIG. 8

FIG. 5. SWING CHECK VALVE IN STEAM LINE TO OIL PRESSURE TANK

FIG. 6. DAMPER TOO SMALL FOR BREECHING

FIG. 7. PLAN OF BREECHING THAT GAVE DRAFT TROUBLE

FIG. 8. SECTION THROUGH STACK SHOWING ACCUMULATION OF SOOT

The steam connection for the pressure tank was connected into the main steam pipe to the engine, as shown in Fig. 5. In disconnecting the steam pipe of the pressure tank one day, we found a little cylinder oil in the pipe near the tee, A, and this made us think at once what was the cause of the oil getting into the boiler. We decided that whenever the pressure in the boiler would drop entirely, such as from Saturday night until Monday morning, it would form a vacuum in the main engine pipe, when a little oil would find its way into the steam pipe and boiler. To prevent this, valve B could have been closed at night when it was known that the steam pressure would drop entirely before steam would be raised again; but this, perhaps, would have been overlooked at times, so to make sure, we placed a swing check valve near the tee A, which would be closed whenever a vacuum would be formed in the main steam pipe. After this, no more oil was found in the boiler, showing that the trouble had been found.

After this a new trouble appeared, as the clapper in the swing check valve would make a loud clicking noise at each opening and closing of the engine valve, which could be heard in the boiler room. It took some time to find a remedy for this, until one day I hit upon the idea of moving the valve farther away from the tee. After this change was made there was no more noise.

Stack Damper Too Small

In a steam plant where it was necessary to bank the fire under the boiler at night after shutting down time, they used to have much trouble with the steam pressure running up quickly in the early part of the night with all the drafts closed off tight and the stack damper closed tight, also the fire banked well and ashes thrown over it. The fire would be almost burned out the next morning and the steam pressure nearly gone. The fire was banked in many different ways with no better results.

The engineer could not find what the trouble was, so asked my advice. In looking over the boiler such as the ash doors, damper and its connections, I came to the conclusion that the damper was too small, as there was too much space between the damper edges and opening in the stack connection, as shown in Fig. 6 at A, B, C and D. This would allow too much draft even when the damper was in the closed position, and opening the fire doors. It could easily be noticed that there was too much draft in the boiler furnace to hold a banked fire very long. Of course, had the ash pit doors had a tight fit and other places been airtight, that would have helped matters some. To remedy the trouble quickly, I suggest a new and larger damper, so as to close off the draft more after the fire was banked. After this was installed, there was no further trouble either in the fire being burned out or the pressure entirely gone the next morning.

A Peculiar Draft Trouble

In a small power plant consisting of 100-hp. boiler and engine, it was noticed for some time that the draft was getting poorer from day to day for no apparent reason even with the stack damper wide open.

The stack and connections from the boiler seemed to be in first class condition. The most puzzling part of it was that some days the draft seemed to be all right, then again on other days it was hardly possible to keep up the steam pressure. Conditions kept on getting worse, making it necessary to locate the trouble or a shut-down of the plant would be necessary. So an examination was made from the boiler to the stack. The stack and breeching from the boiler is arranged as shown in Fig. 7. It was found that part of the stack and breeching was filled with hard baked soot, as shown at A, Fig. 8, and it took much hard labor and time to knock this baked soot down. Short pieces of ¾-in. pipe with a coupling on one end were placed through the door into the stack, then coupled up by reaching through the door with both hands. This was done until the pipe was of sufficient length to reach the soot, then more pieces were added as needed until the soot was knocked down sufficiently that it came down by its own weight. The trouble in this case was caused

in the following way: The last time the bottom of the stack was cleaned out, it must have been quite full and the fireman doing the work removed all soot that came down and thought that as long as the stack was clear of soot at the bottom and no more came down, all was clear, without giving the matter any more attention. The stack was not clear and the soot kept on filling up until it reached the breeching opening, when the poor draft trouble commenced.

The puzzling part of it was that nobody noticed that very little soot had collected at the bottom of the stack since it was cleaned out the last time, which had been about 6 mo. after it was noticed that the draft was getting poor.

A Troublesome Engine Bearing

Figure 9 shows the main bearing on an old type slide-valve steam engine. The bearing is bolted in the engine bed plate with four heavy cap screws. One day this

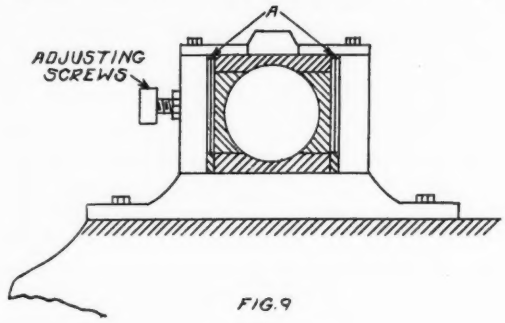


FIG. 9

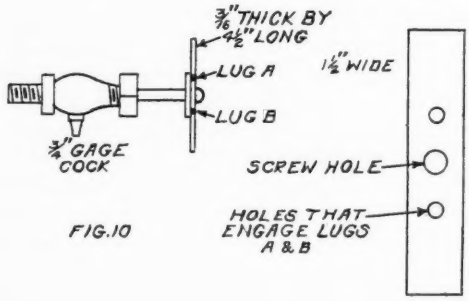


FIG. 10

FIG. 11

FIG. 9. SHIMS USED TO ADJUST ENGINE BEARING
FIG. 10. GAGE COCK WITH PLATE HAND WHEEL
FIG. 11. IRON PLATE TO REPLACE WOODEN VALVE WHEEL

bearing started to pound badly. In looking for the trouble, the engineer found that in some way the two screws for adjusting the quarter boxes had worked loose. In trying to adjust them again, he found that the threads on the adjusting screws had stripped, making it impossible to draw up on the quarter boxes to stop the pound.

My attention was called to the matter, whereupon I found that it was not safe to run the engine in this condition for very long for fear of breaking the bearing. As the engine could not lie idle until the screw holes in the bearing were drilled and tapped for the next size larger screw than was formerly used, we were up against it for a time, when I hit upon the idea of taking out most of the lost motion between the boxes and shaft by driving a number of shims between the quarter boxes and bearing, as shown at A, A. The engine was shut down at once, bearing cap removed, then I placed as many shims as I thought were safe back of each quarter box. The last one had to be driven in with a hammer. After the engine was in service again, not much of a pound could be heard. The engine was run this way until the next Sunday, when the crank shaft was removed from the bearing and the screw holes were drilled for larger screws.

Replacing Wooden Gage Valve Wheels with Iron Plates

In some power plants, gage cocks are used on the water columns, as shown in Fig. 10. These cocks are equipped with wooden wheels which break frequently or they wear out around the holes. When the wheel is in this condition, it is impossible to fasten it again so it will be tight, hence new wheels are necessary. To do away with this trouble, I made iron plates to be used instead of the wooden wheels, as shown in Fig. 11. These plates are about 3/16 in. thick, 1½ in. wide by 4½ in. long. Three holes are drilled in each plate, two fit over lugs A and B and one through which the screw passes for holding the plate to the valve stem.

Lubricant Tests

At a meeting of the technical committee on standardization of petroleum specifications, held in Washington, July 12, new methods sanctioned by the American Society for Testing Materials were approved with the caution that as some of the methods are tentative they should be given careful study before adoption. These new methods apply to corrosion, flash, distillation; sulphur; cloud and pour; saponification in case of fatty oil; water and sediment; precipitation; viscocity "Turol," and melting point tests.

It was decided that the acid test for gasoline and the cold test for steam cylinder and black oils were unnecessary. It was agreed that for emulsion tests on oils of high viscosity, a high temperature should be employed, the details being left for further consideration.

Other matters considered were changes in specifications for service gasoline, definition of grades of kerosene, revision of specifications for lighthouse oil, change of specifications for fuel oil for Diesel engines to allow possible water and sediment of 10 per cent, but with price penalty for all above 1 per cent, change of standard temperature for viscosity tests, greater definiteness in tests for emulsification, and a system of classifying oils by numbers rather than as light, medium and heavy.

The suggestions are to be revised by the technical committee, then passed on by the interdepartmental committee for approval and publication as Government specifications.

As an example of fitting plant practice to circumstances, a large works in England was operating with a highly efficient condensing engine and superheated steam, getting a kilowatt-hour for 15 lb. of steam. There was a large demand for steam at medium pressure for industrial use, and a change to high-speed engines, exhausting against 60 lb. pressure, the exhaust being used in the plant resulted in a reduction of annual coal consumption from 12,800 T. to 8000 T., although it required 57.6 lb. of steam per kw.-hr.

The Suction Line

How Long Suction Reduces Compressor Capacity. By August Ulmann, Jr.

LONG suction lines are prone to cause serious trouble in the operation of the refrigeration plant, as it is difficult to insulate the piping so that the suction gas will arrive at the compressor in a saturated state. For a dry compression system we are told by the text books that the suction gas should not have more than four or five degrees of superheat to insure dry gas. Excessive superheat rarifies the gas and thus the compressor cannot deliver its full capacity because it takes in a reduced weight of gas on each suction stroke.

The writer recently was called in by a large industrial corporation to consult in regard to some refrigeration equipment in one of their plants that was giving poor results. The refrigeration plant was large and three systems were operated in buildings remote from the compressor plant. The largest system consisted of three vertical, high-speed compressors, motor-driven, of 575 tons refrigeration combined capacity. These machines were used to furnish refrigeration for cooling jacket water down to about 32 deg. F. The cold water was pumped from tanks in a cold room to a building about 100 ft. distant and used in the water-jackets of four batteries of nitrators. It was not possible to use brine as during part of the nitration the jacket water was heated to about 150 deg. F. During this part of the operation the hot water was discharged to the sewer and city water at 60 deg. F. was added to make up the loss. This method of operation saved a large amount of refrigeration that would have had to have been expended if a closed brine circulation system had been used. The system worked well but needed careful operation to get the best results.

A second system consisted of a horizontal, motor-driven compressor of 25 tons refrigeration capacity, cooling brine which was pumped to a building about 150 ft. distant, through a system of closed jackets on a battery of crystallizing pans. This installation had no special features and worked satisfactorily.

The third system, which was the one giving trouble, consisted of a horizontal, motor-driven compressor of 15 tons refrigeration capacity pumping liquor to a remote direct expansion system. The liquor left the condensers and traveled through 565 ft. of 1-in. pipe to four cool rooms on the third floor of a distant building. The expanded gas was returned through an equal length of 2-in. pipe and both lines were not insulated. This was particularly bad as they were exposed to the weather 20 ft. above ground on a pole line.

The question immediately came up as to why this suction line was not insulated and the writer was informed that the loss due to this condition, only 3 per cent, was so small that it would not pay to insulate it. They had come to the conclusion that the direct expansion system as installed could not give results and intended to substitute a flooded system in order to overcome their difficulties. It will be of interest to recapitulate the calculations that finally convinced the management of this error.

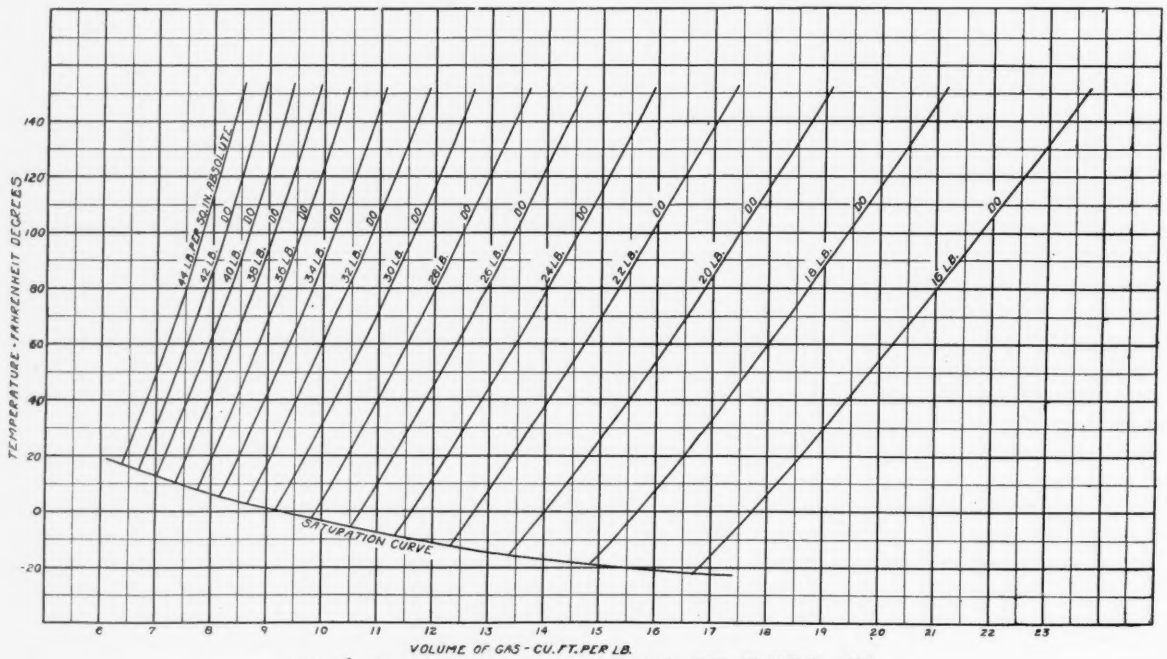


FIG. 1. TEMPERATURE VOLUME CURVES FOR AMMONIA GAS

First the installation was checked as a whole to be sure that it was properly designed. The condensers were ample and the coils in the cool rooms were also large enough. The liquor to be crystallized was fed into the pans in the cool rooms very hot, about 90 deg. C., and it had been found advisable to allow the doors on a recently charged room to stand open for about 6 hr. to allow the liquor to cool down to atmospheric temperature before applying the refrigeration. The rooms were

well constructed and no fault could be found with the insulation.

The rooms were rotated, a freshly charged room being put on each day. Thus, each day the system had to cool down but one room, keep two rooms cold and the fourth room was open with the expansion valve shut off, while the crystal was withdrawn and the pans recharged. The cycle of operation could not be bettered, as it imposed a very uniform load upon the compressor. A calculation on this basis indicated that the compressor should be more than ample, but the facts showed that it was unable to produce an adequate result.

With the capacity available it was calculated that the system should be able to hold two cold rooms at 32 deg. F. and cool down the fresh room in 6 hr., maintaining a suction pressure of about 27 lb. per sq. in. Actually, during the day it was almost impossible to maintain an adequate suction pressure as it ran between 40 and 45 lb. per sq. in. and it was necessary to shut the expansion valves on the two cold rooms in order to maintain even that pressure. No appreciable gain could be made in cooling the hot room until night came and then it was possible to open the expansion valves on the two cold rooms and gradually reduce the suction pressure to about 33 lb. per sq. in. In the morning, again, when a fresh room was closed up and put on the system all the temperatures began to rise and the operators had to begin again fighting to obtain a suction pressure low enough to produce the required temperatures.

As there was no use in attempting to operate at such a high suction pressure as it would not produce the temperatures desired, we set the expansion valves so as to obtain a suction pressure of about 30 lb. per sq. in. and took readings which averaged as follows:

Test 8 a.m. to 5 p.m.	9 hr.
Average suction pressure	29 lb. gage
Average discharge pressure	190 lb. gage
Ave. temp. suction gas leaving cool rooms	19 deg. F.
Ave. temp. suction gas at compressor	108 deg. F.
Air temp. in shade	90 deg. F.
Air temp. in sun near suction line	115 deg. F.

It was hard to maintain the suction pressure at 30 lb. per sq. in. and the refrigeration accomplished was entirely inadequate as the two cold rooms were shut off and the hot room dropped only 40 deg. during the test (from 90 to 50 deg. F.). The frost on the suction line showed only where the piping was protected by the process building and the balance of the line was so warm that it did not even sweat.

The temperature of the suction gas, 108 deg. F., indicated a superheat of

$$108 \text{ deg.} - 16.4 \text{ deg.} = 91.6 \text{ deg.}$$

16.4 deg. being the temperature of saturated gas at 29 lb. per sq. in. gage.

The volume of saturated gas per lb. at 29 lb. per sq. in. gage is 6.38 cu. ft. The volume of the superheated gas per pound at the observed temperature and pressure is 7.92 cu. ft. These values are taken from the curve, Fig. 1, plotted from a standard table of the properties of ammonia gas. The per cent increase in the volume of 1 lb. of ammonia gas due to the superheat is

$$(7.92 - 6.38) \div 6.38 \times 100 = 24.1 \text{ per cent.}$$

thus the compressor, running at constant speed, could compress 75.9 per cent of the weight of ammonia gas which it would normally handle were the suction gas saturated.

The loss due to the heat added in the long uncovered suction line was calculated as follows: The total heat of 1 lb. of saturated gas at 29 lb. per sq. in. gage is 542.8 B.t.u. and the total heat at the same pressure with 91.6 deg. F. of superheat is 595.5 B.t.u. Thus the per cent loss per pound of gas due to this addition of heat is

$$(595.5 - 542.8) \div 542.8 \times 100 = 9.70 \text{ per cent.}$$

This loss in itself is not so large and anybody not familiar with refrigeration might be led to believe that the system could not be seriously upset by it alone. But the consequent loss in the compressor due to the rarification of the suction gas, shown to be 24.1 per cent, could easily upset the operation of the system and produce the symptoms observed.

From this it can be seen how important it is to have the suction line properly covered to insure saturated gas at the compressor suction. Figure 2 is a plotted curve showing how the per cent in density of a pound of ammonia gas increases with the superheat. The curve is plotted for one pressure only 29 lb. per sq. in. gage or 44 lb. per sq. in. absolute.

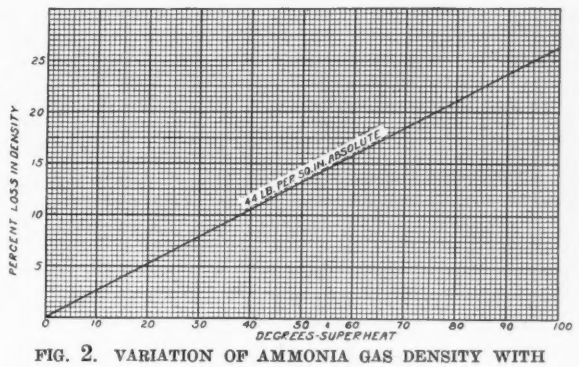


FIG. 2. VARIATION OF AMMONIA GAS DENSITY WITH SUPERHEAT

There are further losses in the compressor due to excessively high temperatures which were not calculated for this particular case, but they would be evident to the practiced operator as excessive quantities of oil were required. The cylinder-heads were coated with a carbon deposit and the valves and valve stems suffered badly. When the suction line was covered the system came up to specification and was able to do the work very acceptably.

IN DISCUSSION before the Institution of Civil Engineers of Great Britain on improving power factor of electrical circuits, it was stated that rolling mill motors usually contribute to low power factor on account of the great amount of time that they run idle. It was questioned whether it is worth while to try to get a power factor higher than 0.8 on a system, because the cost of motors or synchronous condensers for raising the value is so high, from $7.50 to $12.50 per kw. of motor capacity to raise the power factor from 0.8 to 0.95. But in one case it was shown that the loss from bad power factor was $17 per kw., and for such a case improvement would pay.

THE ONLY influence worth having is the influence you yourself create.—Forbes Magazine.

Emergency Jobs

FIGURE 1 illustrates how a repair job, on broken bolts in the frame of a Corliss engine, was accomplished in short order. The original bolts had been put in place before the quarter boxes and shaft were put in place and the nuts were on the outside. This engine had run away and the broken bolts did not show up until about a week afterwards. The first indication I noticed of anything wrong was a clicking sound in the cylinder which gradually became louder. At the same time the cylinder kept rocking more and more upon the cast-iron horses on which it was placed. I immediately started to investigate but did not learn anything until after crawling up on top of the frame to where the joint was. There I could see it open up about ¾ in. at every stroke. I shut down at once and called the chief and master mechanic. Upon their arrival, I took off the cap on the main bearing and the top and side of the quarter boxes.

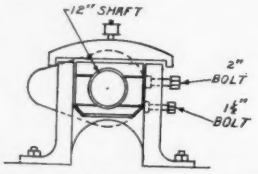


FIG. 1. REPAIRS TO FRAME BOLTS OF A CORLISS ENGINE

While this was in progress, the master mechanic had ordered some 35-ton jacks brought over from the machine shop, the idea being to jack the shaft up high enough to pull the bolts back into the space in the main bearing and put new ones in the same way. After looking at them for a while I suggested that the heads be cut off the old bolts with the acetylene torch and new bolts made with threads on both ends. This suggestion was adopted and the bolts were made and replaced in about 6 hr.

I was told afterwards that it took about that long to jack the shaft and flywheel up and nearly as long to let it down, when the bolts broke on a previous occasion. The only trouble encountered was on the lower bolt; we had to cut a notch in the edge of the bottom quarter box, but the casting was thin and this took only about 10 min., to allow the old head to be taken out and a new nut put in.

Figure 2 illustrates an emergency arrangement for obtaining water for boiler feed purposes when the city supply ceased. The pond shown in the sketch was used to dump logs in and the water as a consequence was very dirty, causing the boilers to foam badly. Usually the water level in the fresh water reservoir and the pond was kept up by the overflow from the city reservoir, which was piped about 1½ mi. to the mill; but in the summer, owing to the increased water consumption of the city, the city reservoir ceased to overflow, and immediate measures were necessary to insure our boiler feed supply.

A 3-in. siphon was connected up as indicated, discharging into the line that came from the city reservoir. Quite a little excitement was had while connecting it up. The water from the underground stream was very cold and after trying various ways of getting the last piece of suction pipe screwed together without success, I stripped and piled in. The job was completed in a short time but of all the cold water I ever came in contact with that was the coldest, but somebody had to do it, and I never believed in talking for 2 hr. on a 5 min. job, no matter how disagreeable it was to do.

Another case that came under my observation not long ago, and looked as if somebody forgot something, was of an electric light plant just installed, consisting of two 500-hp. water-tube boilers to generate steam for a 1250-kw. turbine, with all auxiliaries. The main to supply the boiler feed water was not completed when it became necessary for the plant to start, as the load had to be taken over at a certain time. There was a water main supplied by a 2500-g.p.m. pump as part of the fire protection and water supply system for another concern, only a few feet from the electric company's

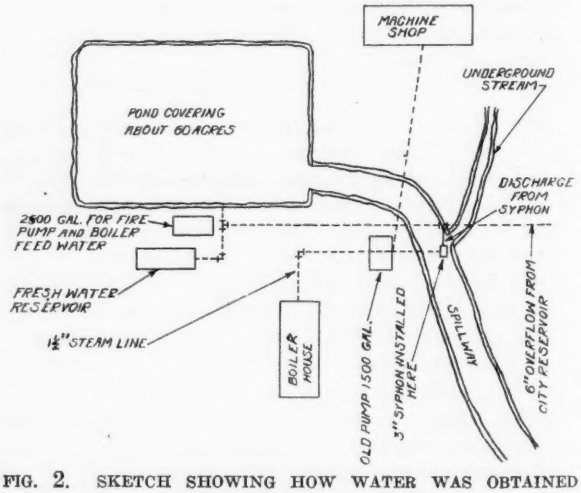


FIG. 2. SKETCH SHOWING HOW WATER WAS OBTAINED WHEN CITY SUPPLY FAILED

main. Both were wooden pipes. Holes were bored in the pipe and one 1-in. and one ¾-in. pipe connected to the electric company's main from the mill supply; 40 lb. pressure was carried on the mill main.

Shortly afterwards the engineer from the electric company hurried over to the mill to see if the water was shut off or if the pump had stopped. This was

followed by some "rush" work in installing more *jumpers* across from main to main. This was comparatively simple, as a hole could be bored in the wood pipe nearly through and the jumper pipe driven in with a sledge, holding a block of wood on the end of the pipe. After six more 1-in. jumper pipes were put in we obtained plenty of water. OPERATOR.

Packing Friction

THE WRITER has been interested in reading an article, "Packing Friction," in the July 1 issue, submitted by A. C. Waldron.

From a practical standpoint the methods submitted by Mr. Waldron for determining the packing friction are very ingenious; however, it is thought that an element of error arises which reflects on the friction characteristics of the packing.

From Mr. Waldron's article, it is assumed that the scale connecting the crosshead and the piston rod registered 753 lb. at the time the piston rod "started to creep," as the flywheel was moved. The element of error apparently entering by this method of estimation is due to the fact that the "inertia effect" is not considered: the "inertia effect" of the moving parts themselves, as well as the sum total (inertia) of the friction on the various moving parts—including that of the packing.

The "packing friction" in which we are directly interested is the "moving friction" when the machine or engine is operating normally. The moving friction is conceded to be a much less quantity than the starting friction, that is, the "friction of rest or impending motion" is greater than the "moving friction" by reason of a different "coefficient of friction" applying in the latter instance. It is thought that the results obtained as disclosed in the former article are excessive in so far as they attribute the figures shown as a "continuing friction loss" to the operation of the engine.

The packing manufacturer is interested in a product having two main characteristics; that is, a low coefficient of friction, and an inherent resiliency which causes the packing to bear easily against the rod. Of course different operating conditions require different treatment and for some equipment there must be a compromise so as to obtain the best results.

LEROY D. KILEY.

Instruments as Fuel Savers

THE LAW compels the owners of steam boilers to have each unit equipped with a steam gage and safety valves as a preventive against loss of life and property. This we know is proper. But there is no compulsory law to prevent the waste of fuel, although there has been suffering and even loss of life caused from the want of this necessity and there have been many instances where this could have been avoided if the supplies that were on hand had been used in a manner that would have made it last over the critical point. There is equipment made that is just as important in the operations of steam boilers according to their uses as the steam gage and safety valve. These are the instruments and regulators which control the different conditions which take place in and about the different units in a power plant.

Power plants, large or small, that are not equipped with instruments and controls for the conserving of fuel are operating on a slipshod inefficient basis by making steam in a manner and wasting fuel in a like manner to keep the plant operating. The waste that is going on in some of these plants is as high as 40 per cent of the fuel, the chimney dampers will be found in a wide open position at all times and in some cases there are no attachments to the dampers to operate them by hand. It is possible to control draft by hand and obtain a high per cent of efficiency from the furnace and boiler; but where there is one plant in which this is carried out faithfully with an object in view to conserve fuel, there are one hundred that do not.

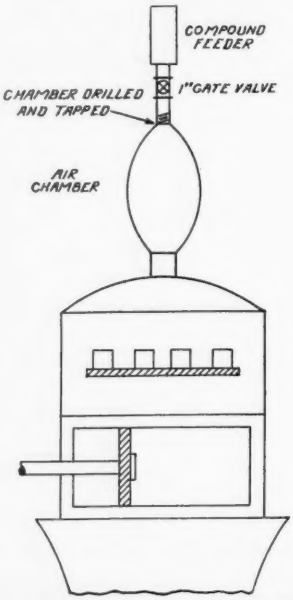
I stated that there is as high as 40 per cent of the fuel wasted where there is no control or attempt to control the different operations. Three 350 and two 325-hp. boilers equipped with side feed stokers without instruments or control for the conserving of fuel, are putting 130 tons of coal through the furnaces a day and are not developing the rated horsepower. On analyzing the flue gases, the average showed 4 per cent CO_2 with a temperature of 600 to 700 deg. F. In this plant there is no attempt to regulate draft or stoker feed. The coke and coal (I cannot call it ash) that was taken from the ash pits was hauled away by those who wished to use it for filling. In cases where it was dumped in driveways the residents shoveled it into their basements to be used as fuel in their furnaces.

A damper regulator is a cheap piece of equipment to install whatever the price may be, in comparison to the saving and benefits derived, and it is immaterial what the size or the design of the plant may be or for what purpose the steam is used; it requires fuel to make it and there must be regulation to make it efficiently. Some manufacturers of these regulators claim a saving of 10 per cent of the fuel by having their instrument installed. I do not know whether this figure was obtained by test or whether they do not wish to claim too much for their regulator; but I know of instances where damper regulators have been installed and the savings made is as high as 30 per cent of the fuel with all credit due to the regulator. When we visit a boiler plant which is not equipped with draft gages, we know there is waste going on without looking further or asking questions.

The draft gage is not given the credit or attention due it in some plants; a draft gage properly installed at the furnace and last pass of a boiler will tell us more what the conditions are from the ash pit to the uptake than we would ever know without, tells us whether we are burning our fuel efficiently; it tells us the different conditions in the furnace which enable us to keep our furnaces at the highest point of efficiency. Any plants large or small that are not equipped with draft gages and giving them the proper attention, must be classed with the wasters of fuel. There are flow meters, CO_2 machines and other instruments and devices to aid us in the conserving of fuel and whatever the cost may be to have them installed in the power plant is a small item compared to the saving made by them in fuel. There are many different designs of stokers, furnaces and boilers made to produce the highest efficiency possible with the least fuel; but with the very best of these we must have instruments and controls to guide us to burn fuel efficiently. CHAS. J. MILLER.

Compound Feeder Causes Pump Trouble

At one of our plants, the engineer complained that he could not throttle the boiler feed pump down so as to keep an even water level in the boilers. Thinking that a smaller pump in my own plant would work better for him and that I could use his pump in my plant, we exchanged and when put to working again I experienced the same difficulty as he had. I reset the valves and did everything I could think of, but to no avail.



COMPOUND FEEDER ON AIR CHAMBER

We had a boiler compound feeder on the suction line to the pump and for some reason the suction became clogged, so I took the feeder off the suction line and put it on the air head as shown in the accompanying sketch. Now I find that I can throttle the pump down to any speed I desire and it works satisfactorily and the compound can be fed in any quantity that is needed. Wm. C. Funk.

Hotel Water

Being in charge of a hotel power plant, I was naturally much interested in the article by George Talcott Ingersoll on the condition of the water system in a hotel plant, especially the part relating to leaks and losses which mean wastage.

This is a winter resort hotel catering to the best tourist business and our loss of water is a constant source of annoyance. We pump our water from two artesian wells to an elevated tank which serves every department as well as the baths, etc., throughout the hotel proper, six cottages and helps' quarters. All the basin cocks are self-closing, avoiding waste if kept in good condition, while the bath cocks, being of the compression type, are often left running and nobody seems to care. We can stop and avoid waste through defects in the plumbing, but we cannot overcome losses through the carelessness or indifference of the guests or their attendants, for it often happens that when a bath is "drawn" and the temperature is not exactly right, being either too hot or too cold, the waste plug is pulled, the tub drained and the operation again repeated, and this represents two losses, one of water and one of heat, and the worst of it is that we cannot stop it; we can furnish the supply, but cannot control the demand or wastage. Especially is this true where the guests are concerned, and we cannot in every case avoid waste by the hotel help.

We use telegraph cocks in our kitchen department which are all self closing, but the help have acquired the trick of sticking an old knife or spoon under the end of the lever handles to keep them open while they run water and go off at some other work. Invariably there is waste with such practices and with the most careful scrutiny, we cannot prevent waste in the water supply or control the amount consumed in and around a hotel; therefore, the efficiency of a hotel power plant cannot be solely judged thereby. In every hotel, there is a great waste of water and from long and careful observation the writer has found that if the heads of the various departments themselves do not co-operate with the engineer in saving light, heat, etc., they certainly will not try to effect a saving in water and any device that will overcome waste of water, be it gyroscopic or otherwise, will be welcomed by many.

Chas. L. Riecke.

Trouble With Motor-Driven Pumps

Recently we purchased three sets of small motor-driven circulating pumps, each mounted on a common bed plate and each with its individual motor and connections. Two of these pumps started off and performed beautifully with practically no difficulty at all, while with the other we had all sorts of difficulty in keeping the stuffing-boxes tight, preventing the motor from heating up, and also because of excessive wear and erosion of the rotor shaft. After trying for several months all sorts of suggestions and expedients, we were about to remove the set and send it back to the manufacturer for replacement when we discovered the source of trouble. When the set was being unbolted from the foundation and the bolts were being loosened, we noticed that the bed plate sprung up with the bolt as it was loosened up, and investigation finally showed that when the concrete foundation was set it was not made perfectly level, a high spot being formed near the center. When the erectors set the pump, they did not notice it but bolted down the pump to the foundation, and when the bolts at each end were drawn up they pulled down each end of the bed plate and consequently sprung the entire structure, as a result of which the difficulty from disalinement was experienced.

We returned the pump for overhauling, chipped the foundation level, and the pump was returned, put in place and has operated satisfactorily ever since. This point is an important one to bear in mind in connection with the installation of any small pumping unit, for frequently the bed plates are not made sufficiently rigid to insure proper support. M. A. Saller.

Hazards of the Extension Cord

The extension cord and the portable electric lamp are used considerably around the power plant. They enable the electric light to be taken where needed with

the least trouble and as necessity arises. Yet both the cord and the lamp are hazards unless due precaution is taken.

Three men, to the writer's knowledge, have been electrocuted in boiler rooms because of the extension cord. The insulation had become frayed and the lamp socket became charged and the electric shock proved fatal. This condition is very liable to occur where electric wires are used around apparatus and where hasty repairs are under way, as ordinary precautions are forgotten in the haste to get apparatus operating again.

It should be the duty of someone in every power plant to accept the responsibility for maintaining portable lamps and extension cords in good condition and free from defective insulation and live, exposed parts.

In one instance, two men entered a furnace with an extension lamp supplied with a 220-v. lamp from the exciter bus bar. The one man completed the circuit between the live side of the exciter system and ground as constituted by the furnace grate bars. He was electrocuted and the second man in going to his rescue also lost his life. In this case, the morals are twofold. Lamps requiring higher than 115 v. should not be used for extension cords in the first place; cords and fixtures should be maintained free from exposed live parts in the second place.

In the second instance, to the writer's knowledge, the fireman was found lying beside the fire door of a dead boiler. He had been making repairs to the fire door refractory. The extension cord was in his hand and his position indicated that he had fallen while his other hand had rested against the boiler front. His body formed the circuit between the live wire and earth, in this case, about 115 v.

The boiler room is a place where special precautions ought to be taken against electric shock, as a little consideration will show. Electric shock in the boiler room tends to be full line potential, that is, the full voltage between the live wire and the earth. Boilers, stokers, grate and other metal work are at ground potential, as all are in intimate and rigid contact with the channel of the structure and with the water pipes—which are the best form of ground or earth obtainable. The presence of moisture and ash under foot, soaked in water and acid, all combine to create a first-class ground.

The majority of circuits for lighting are earthed on one side so that when contact is made between earth and the ungrounded side of the circuit, full line voltage is impressed across the body. The shock is thus very severe. Just how severe the shock is for a given voltage depends upon the resistance of the skin, the path taken and other factors affecting the human body. In working around the boiler room, men are often perspiring so that the resistance to flow of current is low. This means that electric shocks around boiler rooms are particularly hazardous.

The remedy is, of course, to handle extension cords carefully, maintain them properly and not abuse them. An occasional warning as to the need for care is always worth while. Lamps should, obviously, be protected by a lamp guard; handles should be well insulated and the voltage of the circuit should be limited to 115 v.

R. K. Long.

Induction Motor Connections

The accompanying diagram showing connections of an induction motor and starting compensator includes changes which I found necessary to make in order to connect the line wires directly to the oil switch and to place the fuses or relay meters, etc., on the "dead side" when not in operation.

I found this method of connection necessary when installing a 2300-v. motor in a paper mill where the service had to be metered and where it was imperative that the instruments be accessible as well as protected from lighting, etc., when not in service.

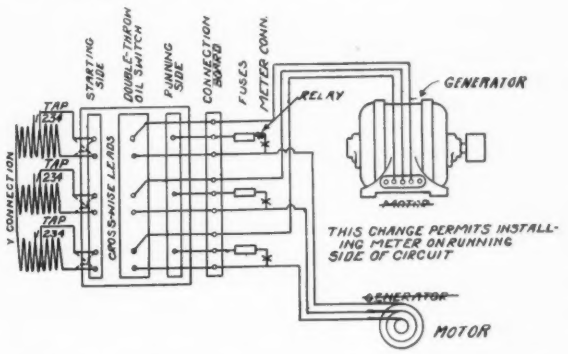


DIAGRAM SHOWING ALTERATIONS IN INDUCTION MOTOR CONNECTIONS

I do not understand why the "National Code" has not required the service wires to run directly to the oil switch as they do in similar cases.

W. T. Hardy.

Traps vs. Pumps

I read with considerable interest the article in June 1 issue, page 583, by Mr. Reed, and some of his deductions I do not agree with. The plant where I am in charge is a pretty fair example of the average type with many different elevations, etc. When I first took charge, the heating system was of the gravity type and never gave satisfaction. Part of the returns were handled by a return trap and part by a receiver and pump. It used to take from 1 to 3 hr. to heat the division of the heating system handled by return trap with from 5 to 15 lb. pressure on the mains and the part handled by the pump and receiver was always giving trouble. About 3 yr. ago we changed everything over to a vacuum heating system. Expansion traps were put on all coils and the return lines all gathered into one header connected to an 8 by 8 by 12-in. vacuum pump, and the discharge from the pump is put into an open feed-water heater. The water from this is handled by a pump for boiler feeding and gets around 220 deg. Some of the coils in this heating system are in a basement and 3 ft. lower than the pump.

Now, I do not say that a return trap system is not the proper thing in some cases, but how am I going to get that condensation back to my engine room unless I use at least two traps, and if it is to be returned to boiler direct, three would be necessary? Also, what would be done with the surplus water that has to be taken care of when steam is first turned on, heat being turned off at night and when the system is turned

on, the condensation will overflow the boilers? This was tried once, before I came to the plant, and the water came back so much faster than used that the only way they could dispose of it was to let it out through the blowoff of boiler, and it was stone cold at that.

We have the one pump to handle all the returns from between 30,000 and 40,000 sq. ft. of radiation; 3 lb. pressure by gage is the maximum carried. Some of our mains are nearly 500 ft. long, going across street under railroad tracks and almost every place imaginable. We always had trouble before we installed the system in its present shape and have had coils freeze up right in the middle of the day with 10 lb. pressure on heating mains. Now we can heat up any section in a very short time with less pressure than formerly, and not as much trouble with repairs either. As to cooling water for the returns, a ½-in. water line is tapped in back of the vacuum pump and is never open more than a quarter turn. The vacuum pump has been packed once a year and no more since installed and one set of valves put in in 3 yr. and they look good for at least a year more. In my particular case I contend that the system of handling the heating problem is the best that can be got, although if my boilers were lower than any point of heating system, a trap would be all right. We use the exhaust from a 20 to 24-in. engine, running 200 r.p.m., for heating the buildings, dry kilns, and feed water.

FRED S. RUTLEDGE.

Oil Grooves in Bearings

SAM BOW has written an interesting and instructive article which appears on page 731 of the July 15 issue, under the caption "Lining Bearings." The manner in which he recommends cutting the oil grooves in the bearings is not, however, according to my ideas, particularly as he makes no qualifications for different bearings.

I am aware that there are many different designs and ways of cutting oil grooves, and also that they seem to give satisfaction. A bearing, or a number of bearings, in a machine may appear to run satisfactorily with any kind of oil grooves, or without any grooves at all, as long as oil is fed in some way or other to those bearings; but this does not prove that there may not be a best way to cut grooves for certain existing conditions. An analysis of all attending conditions should first be made before deciding how oil grooves should be cut, in order to attain best results.

The principle of correct bearing lubrication demand the formation and the maintenance of a continuous, unbroken film of oil between the frictional surfaces. The purpose of oil channels or grooves cut in the surfaces of a bearing is to conduct the oil to the various parts of the surfaces to be lubricated. Poor design, the result of guesswork or poor analysis of conditions and requirements, is recognized by its complex and elaborate nature. Such grooving will generally defeat the very purpose for which it was devised, breaking up the oil film and conducting the oil away from the important points rather than leading it to those points and enabling it to stay there.

Good design in the layout of oil grooves is noted by its extreme simplicity. This will give most effective oil distribution and the formation and maintenance of an oil film. Under certain conditions some bearings do not require any grooves at all. The factors which influence the design of oil grooving are as follows: Method of oil application, point or points of application, pressure endured, speed of revolution, design and size of bearing, direction of rotation.

A short bearing, say, 6 in. or less, provided with a single oil hole in the center of the cap, and fed with oil from a sight feed cup, does not require any grooving other than the regular chamfered edges, which should be given all bearings. If a bearing is much longer than 6 in., two oil cups should be provided; or if only one is provided, then a longitudinal oil groove should be cut in the upper, or cap, part of the bearing extending each way from the oil hole, to within ½ in. of each end of the bearing cap. Generally speaking, the bottom bearings do not require and should not be given oil grooves at all. The chamfered edges that are so familiar to engineers and other attendants, are full and sufficient to distribute the oil to the bottom half. The chamfer causes a wedge-shaped body of oil to collect, and the tendency of the revolving journal is to drag in and keep dragging in that wedge of oil, which joins the desired firm, which separates the metallic parts. Now, if there were an oil groove in the bottom bearing, such as illustrated by Mr. Bow, the film would surely be broken at that place and metal-to-metal surface must follow.

Again, an oil groove in the bottom box reduces the bearing surface, which in some designs can be ill afforded.

Simplicity should be the keynote in designing oil grooves for all bearings. Cut as few as possible and cut none at all where possible. Always analyze conditions and study requirements before doing any cutting. The method of applying the oil and, indeed, the *kind of oil*, have much to do with how an oil groove should be cut in any given bearing.

CHARLES J. MASON.

Excessive Thrust of Centrifugal Pump

A FOUR-STAGE boiler feed pump developed excessive end thrust when first put in service. Thrust bearings were repaired and renewed, but the condition was not improved and it appeared to be in the rotor. A new rotor was installed, but the same trouble continued. It seemed very difficult to account for this end thrust, as no defect of the pump had been located.

After going through the pump several times, it was found that the lower half of the casing was wider than the upper half in several places where the two castings joined. This made a little shelf that projected into the whirling water near the impeller. The water which was circulating at high velocity was deflected from this shelf against the impeller, causing an end thrust.

The upper and lower castings were carefully marked at the joint, and these were then chipped and filed so as to match both top and bottom casings at all points. This made a perfectly smooth wall for the water to travel against and did not cause the water to be thrown against the impeller. The pump has given good service without trouble since the above repair was made.

T. H. E.

Air Line Explosion

AN ARTICLE in the April 15 issue of Power Plant Engineering dealing with air line explosions called to mind one that occurred in a Diesel engine plant in southern Massachusetts some years ago.

As is customary, this line carried a maximum pressure of 1200 lb. per sq. in. which was compressed in a three-stage machine and the high-pressure discharge line became very hot in spite of intercoolers between the first and second, and second and third stages and a water jacket around part of the discharge pipe. At times a quick pop of the high-pressure relief valve had been noticed when the plant was running, and smoke would come from it as if a light explosion had taken place.

On the discharge line, just beyond the cooler, was a check valve so that there could be no return flow into the compressor and at the time of the explosion a one-inch extra heavy steel pipe connected the compressors to a battery of 12 steel reservoirs and this was laid temporarily on the floor and had a number of fittings in it in place of the usual couplings.

When shutting down for the noon hour it was customary to see that the reservoirs were charged at full pressure and then the stop valves were closed and the compressor was stopped as soon as the air going to the engine was closed off. While there was a relief valve on the compressor, it will be seen that if it was unlikely that an over-pressure would be pumped, if there was anything to cause such a condition in the line, the check valve next to the compressor would render the relief valve on the discharge chamber powerless to prevent any trouble.

Thus it is apparent that the explosion occurred just at the time when there was no air being supplied to the fuel valves of the engine and also when there was no large volume in the reservoirs for expansion. The effect was similar to what might occur if a gun barrel was plugged and the gun discharged; something had to go, and as a consequence six fittings, all made for 2000 lb. pressure, ruptured with a tremendous report and clouds of dust blew from the building housing the engines and compressors.

The particles of steel had force enough to puncture oil barrels and boxes and other articles lying on the fittings were shattered. At one point there was an inch standard weight pipe that was laid alongside one of the fittings that had a plug in it and the light pipe was split and badly dented by the plug. While the writer and his assistant were working close to the pipe, no pieces large enough to be dangerous touched us, although there were clouds of dust. The assistant was standing on a plank over the fitting that damaged the inch pipe so badly and the force of the expanding gas was sufficient to lift the plank and threw him several feet from it.

There are always all sorts of theories about what causes such an explosion, but it is quite probable that the lubricating oil used in the compressor had become vaporized and possibly there was some dust along with it and so the heat was sufficient to ignite it by spontaneous combustion similar to what takes place in the cylinders of the engines that were supplied with air through the pipe line, and when the flow of fresh air was stopped the trouble commenced. A relief valve on the line would have doubtless prevented the trouble since it would have provided a vent for the gas formed by the heat. If the line had been permanent, there would have been one installed, but such a contingency was not thought of, as it was felt that the compressor would not pump an over pressure with its own relief valve. A valve was put on when the pipe was repaired, however, and it was fortunate that there was no greater damage done.

G. H. KIMBALL.

Regulator for Fan Engines

ENGINEERS who have in their plants a draft system which necessitates a regulator to control the fan engine can save themselves a great deal of annoyance and expense by simplifying their regulator as illustrated.

If you have a 1½ or 2-in. balanced throttle valve, you can do away with a hydraulic cylinder on the regulator; this will save a great deal of water and will eliminate the renewals of the small needle valve which I find in my experience cuts out rapidly, rendering the regulator inactive.

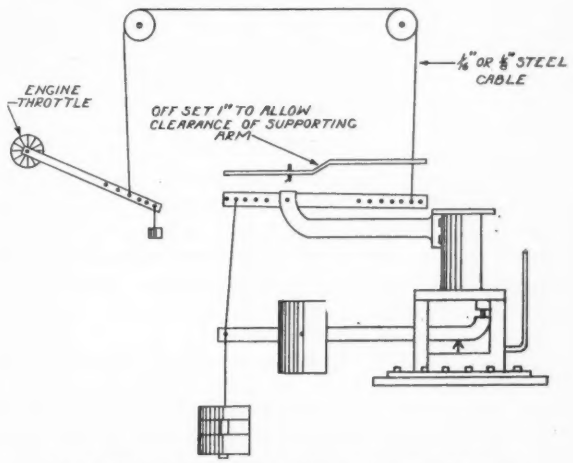


DIAGRAM OF REGULATOR FOR FORCED DRAFT FAN

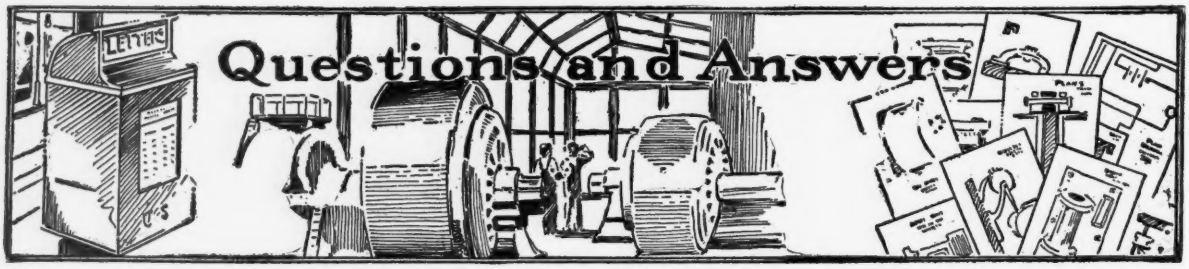
In this arrangement, there is nothing to wear out except the diaphragm and it will last for years. Be sure the throttle valve works easily; take it out and polish it until it will work without any friction. The desired travel can easily be gotten for the throttle lever by means of the holes provided for making adjustments.

Be sure the knife edges on end of the long weighted bar and diaphragm bearing edges are sharp; give them plenty of clearance so the bar will respond when steam pressure lowers and rises.

I experimented two days before I got what I wanted in regulation. Now it works perfectly and the boilers seldom pop.

OAKS KYGER.

RESEARCH WORK to discover methods of fixing nitrogen from air and making it available for use will continue under the Department of Agriculture, being transferred from the War Department. Results will still be available for agricultural, war and chemical purposes. A personnel of 120 is transferred with this work. The sum of $500,000 has been made available from the funds in the control of the President for the next two years, as compared with a previous $300,000 annual budget. The laboratory will continue to be in the building of the American University at Washington, D. C.



Welded Joints for Steel Stacks

IN SECURING bids for a steel stack 42 in. by 72 ft., of 3/16-in. plate, an offer was made to construct this stack with welded joints. What experience have other engineers had with this type of construction? J. J. C.

Boiler Nipples Suddenly Loosen

WHILE RUNNING our 625-hp. Bigelow boiler at about 1000 hp., all the nipples at the bottom of two front sections suddenly became loose and some of the tubes became so loose at the top that they could be wiggled by hand. Could somebody give me a reason for this failure? M. E.

Condenser Corrodes

I AM having trouble with our surface condenser; the action is on the tube ends and ferrules on the inlet side below the baffle and appear bright as if eaten by acid. Also the tubes in the top of the condenser near the steam inlet will get small, clean holes in them from 1/16 to 1/8 in. in diameter and look almost as if they had been drilled.

We are using the condenser to heat sea water for the swimming pool and also circulate from the pool when tide is low. As a disinfectant, we are using chlorated lime and the water would naturally contain hypochlorous acid which when decomposed would produce oxygen gas.

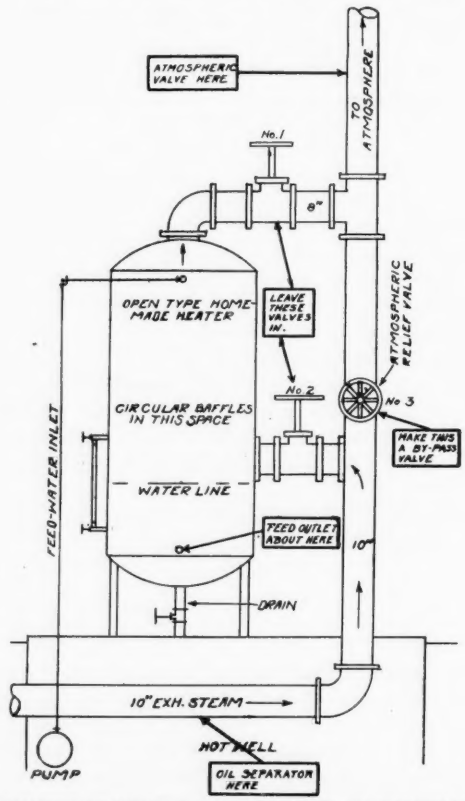
I have carefully gone over the electric end of the plant and can find no leakage, I also have the condenser loaded with zinc plates but show very little action. This is the first season this action has taken place and I have made no change in the working condition of the plant.

I can also state that up to this season the tubes lost weight slightly over one ounce per tube every six months. Length of tubes is 8 ft. and diameter 5/8 in. What experience have other readers had with these conditions and what remedy did you use? F. L. G.

Feed-Water Heater

YOUR CORRESPONDENT A. C. B., page 777, Aug. 1 issue of the paper, presents a problem that interests me. Possibly the following may in turn interest him. If I may, I would suggest that *first of all* he reduce the oil feed to the cylinder—or cylinders—of the engines and other apparatus exhausting into the feed-water heater. Evidently too much oil is being used. If only sufficient oil for the lubrication of the internal parts be used, no appreciable quantity will pass out in the exhaust steam. Judgment, and an analysis of conditions, will enable him to decide just how much he can cut down his oil feed without danger to the parts requiring lubrication. If he will install an atomizer pipe through which the cylinder oil can be fed there is no doubt but that he can materially cut down the quantity fed at present, judging from his statements regarding the quantity of oil getting into the boilers.

Next, in order to take care of any oil coming out with the exhaust steam, he may install an oil separator in the exhaust line, at or near the point marked in the sketch. If that place is not convenient nor suitable for any reason, he may place the separator in the vertical part of the exhaust pipe above the elbow, or possibly he can connect it nearer the engine. A back-pressure



PROPOSED CHANGES IN FEED HEATER CONNECTIONS

valve may be installed in the vertical part of the exhaust pipe, *above* the tee shown in the sketch. A drain valve and pipe should be attached to prevent the accumulation of condensate above the valve.

Valves 1 and 2 should be retained so that the heater may be shut off when occasion requires and the exhaust steam may go direct to the exhaust head. Valve 3 may be retained, if it is suitable for use as a bypass valve to the exhaust head, when valves 1 and 2 are closed.

The feed-water outlet should be near the bottom of the heater, so that if any oil should get into the heater in spite of the precautions before referred to, it will float on the surface of the water and not be liable to get out with the feed. When the engine is shut down the oil and water remaining in the heater may be drained out through the bottom of the heater. Thus the possibility of oil getting into the boiler will be remote. It is a matter of care and watchfulness, after the changes have been made.

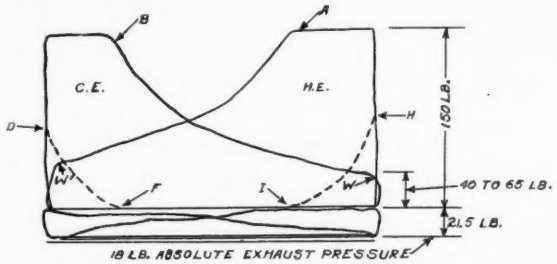
There is no reason why the plan should not work out entirely satisfactory.

The back pressure of 2 or 3 lb. it is desired to carry will give a higher feed water temperature; it will, of course, mean the equivalent of an additional load on the engines, etc., exhausting into the heater. Whether or not that will be any gain by increasing the back pressure can only be determined by actual trial. Approximately speaking, every 11 deg. F. increase in the feed water temperature means a saving in fuel of 1 per cent. When all things are considered, it pays to heat the feed water as high as possible, although there may be cases where this cannot be done, owing to surrounding conditions. In A. C. B.'s case, however, if he finds that he cannot successfully carry any back pressure above that of atmosphere he can easily readjust the valve. But I am of the opinion that he can carry a pound or so. The risk of putting in a back-pressure valve and making the other changes suggested is not great, nor to be feared.

CHARLES J. MASON.

What Should Be the Receiver Pressure

THE ARTICLE of this caption by C. D., on page 734 of the July 15 issue, seems to be a case of valve adjustment of the exhaust valves on both the high and low-pressure cylinders to get a trifle more compression on both cylinders and a case of ratios of pressure to ratios of cylinder areas at unknown points of cutoff. C. D. did not mention the diameter of the cylinders which is of vital importance for accurate figures.



COMBINED DIAGRAM OF COMPOUND ENGINE

The problem is, 150 lb. is to the area of the high-pressure cylinder as the receiver pressure is to the area of the low-pressure cylinder.

He states that the receiver pressure is 21.5 lb. This is too low, as the high-pressure diagram shows no compression at all. Equalize the cutoff on the high-pressure side by shortening the cutoff very slightly on the head end and the governor will then automatically lengthen the cutoff on the crank end an equal amount. The point of cutoff on the low-pressure side seems to be fairly well equalized between the two ends of the cylinder. But the scale of spring used to take the cards was probably too high to give a good diagram. A 30-lb. or 50-lb. spring should have been used to give a larger diagram, which would show up the troubles on that side better.

With a compound engine it is desired to have each cylinder carry its proportionate share one-half of the load. Hence the diameter of cylinders are necessary in figuring this because if the low-pressure cylinder is not twice the diameter of the high-pressure cylinder, than to have the low-pressure cylinder do as much work as the high-pressure cylinder, it would require a later point of cutoff to give a higher mean effective pressure in the low-pressure cylinder than would be required if the low-pressure cylinder were twice the diameter of the high-pressure cylinder. From the size of the diagram, I believe the high-pressure cylinder is doing most of the work, that the steam is going "right through" the low-pressure side, so to speak, as 21.5 lb. receiver pressure is very low in proportion to 150 lb. throttle pressure.

To make the low-pressure side do more of the work, shorten the cutoff on the low-pressure side, this will build up the receiver pressure higher and the higher the receiver pressure the more work the low-pressure side will do on account of higher pressure on the large piston, but should not do more than the high-pressure side. This receiver pressure is to be about the same as the terminal pressure on the high-pressure side, i.e., the pressure in the high-pressure cylinder when the exhaust valve opens, and this receiver pressure is also back pressure on the high-pressure piston.

When the receiver pressure is raised, by shortening the cutoff on the low-pressure side, until the low-pressure cylinder is doing a good share of the work, the governor will automatically shorten the cutoff on the high-pressure side and the terminal pressure on that side will be less according to load and speed. It will be well to take a few cards from each cylinder as these changes are made. The rough guess for receiver pressure when 150 lb. of boiler pressure is used would be 40 lb. and might need to be raised to 65 lb., depending on the ratios of the cylinders and point of cutoff. With a riding cutoff valve on the high-pressure side and a fixed cutoff on the low-pressure side, the receiver pressure will vary with the load and change of the point of cutoff on the high-pressure side. The exhaust valves on the high-pressure side should close earlier in the stroke, about the point F and I, so the compression will run up more on a curve with the dotted lines to D and H, which will make the compressor run much smoother and quieter, if keyed up well on the pins and bearings.

In making this change, it will probably make the point of release at W and W' a trifle earlier, which will be beneficial economically, for the point of release is a trifle late. In changing the main valve to adjust the point of release and compression, care must be used to see that it does not put the riding valve out of adjustment; if so, it will have to be reset also. Then if the valves have been run in one position long enough to wear shoulders on the valve and seat, care must be used to see that the valves in their travel, in the new set position, do not ride upon these shoulders and lift off their seats and allow steam leakage beneath them when they are supposed to be closed.

I regret more data was not given. As it stands it is up to C. D. to use a cut and fit process until he gets the load equally divided between the two cylinders by figuring out the horsepower of the cards at the different pressures as changes are made. When the load is equally divided and the valve setting is correct, the receiver pressure is then what it should be for that amount of load, but will increase or decrease with the load and the point of cutoff. R. A. CULTRA.

Answers to Engine and Boiler Questions

I SUBMIT the following answer to "Engine and Boiler Room Questions," page 777, Aug. 1 issue:

1. The engine would take steam at longer stroke, the amount of steam being less as the valve closed.
2. This cannot be done with the plain slide valve.
3. Some engines would run away and others would stop.
4. Due to additional condensation and an unnecessary volume of steam each stroke.
5. No. Allow a little for expansion. If you don't, you may have stripped rods and nuts.
6. Stokers are considered more economical. There is less draft and less labor.
7. If you refer to stokers of the chain grate type, this is to act as a seal for air currents. With hand-firing you can carry it thicker all around, especially in locomotive type boiler.
8. Valve area 7.068 sq. in.; $120 \times 7.068 = 848.16$ lb. total pressure on 3-in. valve.
9. Head equals pressure times 2.304; $2.304 \times 125 = 288$ ft. head.
10. In installing sight feed lubricators, be very careful in removing them from the packing case. You are supposed to have no steam on the line, also proper sized holes drilled and tapped, both either to be above or below the throttle. Never have throttle between these connections, as when the throttle is closed you have full steam pressure forcing all through the feed glass. This soon empties lubricator. If you use a tip inside the pipe at discharge, have it face up so the oil will dip off the point nearly in the center of the pipe. All connections being fast, fill up, then turn on steam, and as soon as feed glass is full of water adjust the rate of feeding.

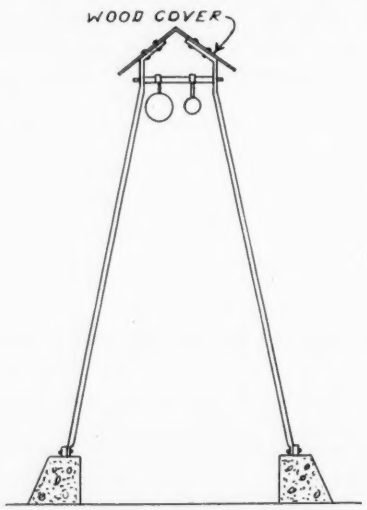
R. G. SUMMERS.

Piping Problem

UNLESS the change in underground piping contemplated by P. M., page 733, July 15 issue, is to do away with a pocket drained by a steam trap where the piping drops 14 ft. to the trench underground and probably, although he does not so state, rises again to enter the main building, it would be well to leave the system as it is provided the trench does not hold water which may at times reach the pipe. Otherwise it would be advisable to run the lines according to the proposed change, but with the substitution of fire felt covering for hair felt and the use of asphalt laid paper applied with hot asphalt instead of tar paper and the paper covering bound with soft galvanized wire 3 in. between turns, after which the cover of paper should be treated to a coating of coal tar and this tar coating should be repeated at intervals.

For the distance of 65 ft. where it is proposed to carry the pipe overhead, the supports for the lines could be cheaply made as noted on accompanying sketch; suitable lengths of 2-in. pipe are flattened at the ends after inserting pieces of 1½-in. pipe to extend a little beyond the flattened part as a reinforcement and which, after being drilled and bolted to the heavy strap-iron lugs imbedded in the concrete blocks would not be perfectly rigid, but would allow of any movement in line with the expansion of the pipes; being free to move hingewise at the bases.

In one installation of this kind which I have in mind, the upper ends of the pipe supports were flattened back enough to be shaped so as to support a V-shaped cover or roof over the pipes and which in turn was covered with roofing paper, making a neat appearance and serving as an extra protection. As no mention is made of steam being generated at two different pressures or at high pressure with the use of a reducing valve in the boiler



METHOD OF SUPPORTING PIPES

room, or if the low pressure mentioned is exhaust steam, since these facts are not given it may be well to suggest the use of but one high-pressure line the whole way, taking low pressure through reducing valves at the branches as desired. CHAS. L. RIECKE.

What Causes Pressure Drop?

IN THE July 1 issue, page 682, is an article entitled "Is There Any Trouble?" in answer to the article in June 1 issue, page 585, by Operator. Mr. Wakeman has figured the maximum output of the machine fairly close, but I will give some figures from the operating log so that conditions may be more clear. The boilers are 72 in. by 18 ft. h.r.t. No. 1 has seventy-four 4-in. tubes and No. 2 seventy 4-in. tubes. They are fired by Jones underfeed stokers with 9-in. ram, width over all 66 in., length from inside brick wall in front to bridge wall 7 ft. 6 in., distance from dead plates to shell 36 in., forced draft supplied by Clarage 40-in. ¾ housing fan, driven by 10-hp. Jewell No. 3 engine, discharge duct of fan 16 in., supply to stokers, 12 in. each, regulation of fan engine taken care of by Kitts 1½-in. regulator. Maximum draft obtainable over fire 0.05 in. of water, draft usually carried 0.015 in. If a quarter draft is

carried more coal is required to do the same work. That draft is sufficient to carry away the products of combustion and maintain the highest average CO_2.

Flues are blown every 6 hr., boilers being equipped with mechanical soot blowers. Boilers cleaned every two weeks. At the time of inspection by the Government Fuel Administration, after looking over my operating records, such as can be kept by using a pair of scales and record of switchboard output, the plant was given a rating of 82 per cent. Have no means of checking feed water used but temperature of the feed water at pump discharge is 160 to 220 deg. F., according to how long engine had been running. Once a month I am required to render a report to the superintendent as shown below:

FUEL REPORT FOR MONTH OF MARCH, 1921

Total coal used for all purposes	249,438 lb.
Total ash removed	42,388 lb.
Ash percentage for month	16.9
Kw.-hr. generated	21,345
Hp.-hr. = 21,345 ÷ .746 =	28,612
Coal for power	144,599 lb.
Coal to maintain heat nights and Sundays	104,839 lb.
Cost of coal in bunkers	$8.00 per ton

Everything will be going along fine, steam 105 lb. gage, fires clean and from 12 to 16-in. deep on retort, water 1½ gage, load holding around 100 kw., ammeter reading 42 to 45, and the trouble starts. Steam will begin to go down as though about a 3 or 4-in. pipe were wide open to the air. If there were any appliances that took live steam in large quantities, I should think that would account for it, but there are not. Everything is on exhaust steam, except two feather renovating machine boilers, containing 100 sq. ft. of radiation each. Steam is supplied through a reducing valve to them at a constant pressure of 20-lb. gage. Condition will seldom last over an hour when things will come back to normal. Have had it start when load was only 85 kw. and steam got down to 65 lb. when load jumped to 160 kw. Within 10 min. steam started to go up and stayed up. There seems to be no particular time or condition of load or weather for the trouble to start. If it were continuous I should think the boilers were overloaded but I don't think the report from log book shows an overload at any time. The biggest card ever taken from this engine figured 282 i.hp. OPERATOR.

Examination Questions for First-Class License

How WOULD you put the spool in the center of the rod of a duplex pump (it having slipped) if there were no marks to guide you?

2. How would you get the piston off a duplex pump if you had tried a lead hammer on the end of the rod and it had proved unsuccessful?

3. How many steam ports are there in a duplex pump? Why?

4. What are compression valves on a duplex pump?

5. How would you change the lead of an American Ball engine without changing any of the moving parts or changing the position of the wheel and still have the lead equal on both sides?

6. How would you find how much clearance there was in a high-speed engine if there were no marks to guide you and you had to start up in a few minutes?

7. Give two reasons for the tubes of a water-tube boiler being inclined.

8. How are the tubes placed with reference to the steam and water drum of a Heine boiler? (b) How much higher is the water in the rear of a drum of a Heine boiler than in the front, the boiler being 18 ft. long? (c) What part of the drum represents the middle try cock or half glass of water?

9. If you put a welded tube in a boiler, where would you put the weld? Why?

10. How is the B. & W. boiler supported?

11. How is the Heine boiler supported?

12. Explain the advantages of superheated steam.

13. Why is it that the Heine boiler has throat braces while the B. & W. has not?

14. Where does the feed water enter the Stirling boiler?

15. (a) Of what material is the shell of a return tubular boiler made? (b) What material is used in the heads? (c) What is the limit of tensile strength of each?

16. Suppose you fitted a new snap ring to a piston of an engine and the ring proved to be too narrow for the recess and every time the engine took steam on that end the incoming steam caused the loose ring to knock, what would you do to stop it without getting a new ring?

17. If you were carrying 28 in. of vacuum and lost it, how much would you have to increase the boiler pressure to carry the same load with the cutoff at ¼ of the stroke or the same as before losing the vacuum?

18. Is there any danger of getting water in the cylinder with a jet condenser? (b) What do they do to prevent it?

19. Is there any danger of water getting into the cylinder with a surface condenser? (b) If so, why?

20. Is there any danger of water getting into the cylinder with a syphon condenser? (b) If so, why?

21. Why are a. c. generator field windings mostly rotor wound instead of stator wound.

22. Of what use is the power factor meter in a power house?

UTAH power and light earnings for June and the 12 mo. ended June 30 compare as follows:

For June—	1921	1920
Gross earnings	$519,609	$490,887
Net	232,524	196,858
Total income	242,769	206,142
Balance after interest	101,248	65,729
For 12 mo.—		
Gross earnings	6,870,905	6,140,880
Net	3,242,475	2,886,885
Total income	3,386,567	3,017,506
Balance after interest and preferred dividends	1,057,776	762,289

J. B. DILLON.

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Interconnection of Power Plants

Probably the most prominent feature of development in the power plant field today is the effort being made by the central station interests to merge their various holdings into an interconnected system thus giving an opportunity to concentrate the development of power into a few extra large power plants advantageously located with regard to fuel and condensing water supply and equipped with the most economical sizes of units and auxiliaries consistent with load requirements and reliability of service. The most recent step along this line is that taken by certain interests in Central Indiana in the name of the Indiana Electric Corporation which has just been formed for the purpose of developing the power industry in that section of the country.

There can be no question but that such a consolidation of interests can work with benefit to the companies and to the advantage of the public, for with state public utility commissions guarding the interests of the people there can be little, if any, danger from a monopoly of these interests dealing unjustly with its customers.

Studying almost any district in the country containing cities and industrial centers of consequence from an engineering viewpoint, it will be found that as a rule the coal mines are away from the cities and condensing water in these locations is limited. Large cities are seldom built up in the immediate neighborhood of hydro-electric power sites; small towns and villages do not furnish load enough for an economical power plant, and thoroughly reliable service; agricultural districts do not use enough power to make special lines radiating into the country a paying investment. The load curves of city central stations are full of peaks and valleys resulting in low load factors. Of course many other special conditions will be met in any engineering survey of a district but those enumerated are the most common and may frequently be changed for the better by the interconnection of local distributing systems into one big district with high voltage transmission lines.

In the Indiana district, unquestionably the location of a super-power station near the coal fields and on the Wabash River will effect a saving in freight on coal, and the necessary transmission lines connecting the larger cities will make practicable service to small towns, villages and agricultural districts, and in many cases eliminate small, uneconomical power plants that are giving only mediocre service.

In many districts of the Middle West, as pointed out by C. W. Place at the spring meeting of the American Society of Mechanical Engineers, improvement in steam central station load factor can be obtained by the development of the water power sites, even those of comparatively small capacity, within an interconnected district.

In regard to reliability of service, interconnection is bound to be of advantage in every instance, for, with a well designed system of transmission, there are always two or more ways of feeding into any important distribution station and should a transmission line or even a complete generating plant fail from any cause, service interruption need be of only momentary duration.

In our enthusiasm for interconnection of central station plants, however, we should not overlook the part played in the power industry by the privately owned

industrial and building power plants. While it is well recognized that in terms of coal per kilowatt-hour delivered to the switchboard the large economically operated central station has an advantage over the small isolated power plant, it is also a matter of record that, in terms of B.t.u. utilized for human interests per pound of coal burned, an isolated plant is, under many conditions, the more economical solution to the power problem of an industry.

While central station managements are looking in every direction for ways to improve load factor and service, and to economize in coal and investment costs, why not give attention to the advantages of inter-connection with important industrial power plants within their districts? This has been done in a few isolated cases but apparently does not meet with the favor of central station managers generally. There has been a spirit of unwarranted jealousy between central stations and isolated power plants; each unquestionably has its individual field and there is no doubt but that an exchange of power service can in many cases be arranged to the advantage of both.

For example, we find that the main peak loads on a central power station occur during that period of the day when people are going to and from work. At this very time industrial plants as a rule are carrying practically no electric load, exhaust steam, however, could be used to advantage at these hours and they could feed current into the public service lines at a very low cost, whereas to tide a central station over these peaks requires an enormous investment in equipment that lies idle a great share of the day.

On the other hand, during off peak periods of the day, for standby service and during seasons when exhaust steam is not needed, the industrial plant can, in many instances, call for service from the central station to advantage. Each plant, of course, has its own peculiar problems and these must be studied carefully, but from the viewpoint of ultimate economy to the community there seems no really good reason why central station companies should have great sums of money tied up in equipment to carry them over a peak load of short duration and lie idle the rest of the day when generating units in industrial plants in their territory are actually being shut down for want of load at those particular peak times.

Off Duty

In these unstable times when the war-scarred world, still upset from her four-year tussle with the war-god Mars, is vainly striving to get "back to normalcy" we are apt to regard anything which bespeaks stability with an uncommon degree of interest. To tell the truth, we didn't think there was "any such animal." About the only things we thought were stable were the high price of coal and the large size of the ash pile. It is, therefore, with considerable attention that we read of the gyroscopic stabilizer on board the new steam yacht Lyndonia, a 100 per cent stabilized vessel.

Until a few years ago, the gyroscope was little known or heard of except as a top (we have all played with them one time or another) although as far back as 1852 Foucault investigated its action and formulated its laws.

Since then, however, the gyroscope has been successfully applied to a number of devices and most of us have heard something about the gyroscopic compass which has replaced the magnetic compass aboard battleship and also of gyroscopic control for torpedoes. Our great interest, however, especially to those of us troubled with *mal de mer*, has been in the application of the gyro to the stabilization of ships. The peculiar property of the gyro which tends to maintain its spinning axis in space has made this seem possible. Little success was obtained in this particular field, however, until Elmer A. Sperry of New York invented what is known as the active stabilizer.

This device differs from the passive stabilizers heretofore employed in that ingenious controls are introduced which enable the gyroscopic forces to become operative instantly after the ship has started to roll.

While a complete explanation of the action of the stabilizer cannot be given here, it is sufficient to say that by artificially tilting the spinning axis of the main gyro either towards the bow or the stern of the vessel, the gyroscopic force can be impressed at right angles to either the starboard or port sides of the ship. In a calm sea, therefore, it would be possible to cause the stabilizer to roll the ship by alternately tilting the spinning axis fore and aft. It is thus obvious that when a wave tends to roll the ship towards the starboard, it is merely necessary to tilt the spinning axis of the gyro towards the bow in order to cause the gyroscopic forces to oppose the force of the wave and preserve the stability of the ship. Each wave, it will be seen, must be anticipated or at least detected in its very early stages in order to be able to apply at the correct instant the counteracting gyroscopic forces.

The device which accomplishes this is an exceedingly sensitive feeler or "control gyro" as it is called. It consists of a comparatively small gyroscope placed anywhere aboard ship apart from the main stabilizer and fitted with suitable electrical control contacts. This little machine detects the wave in its very early stages and also "feels out" its direction. A fraction of a second after the wave has started to roll the ship, the control gyro closes a set of electrical contacts and through a system of relays starts what is known as the precession motor. This latter is geared to the outside of the main gyro casing and performs the tilting or artificial precession referred to above.

The Lyndonia on recent trips has shown increases in speed of as high as 14 per cent since being equipped with the stabilizer. Such remarkable gains cannot be neglected and other results obtained have indicated possible savings of upwards of 30 per cent in heavy weather.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

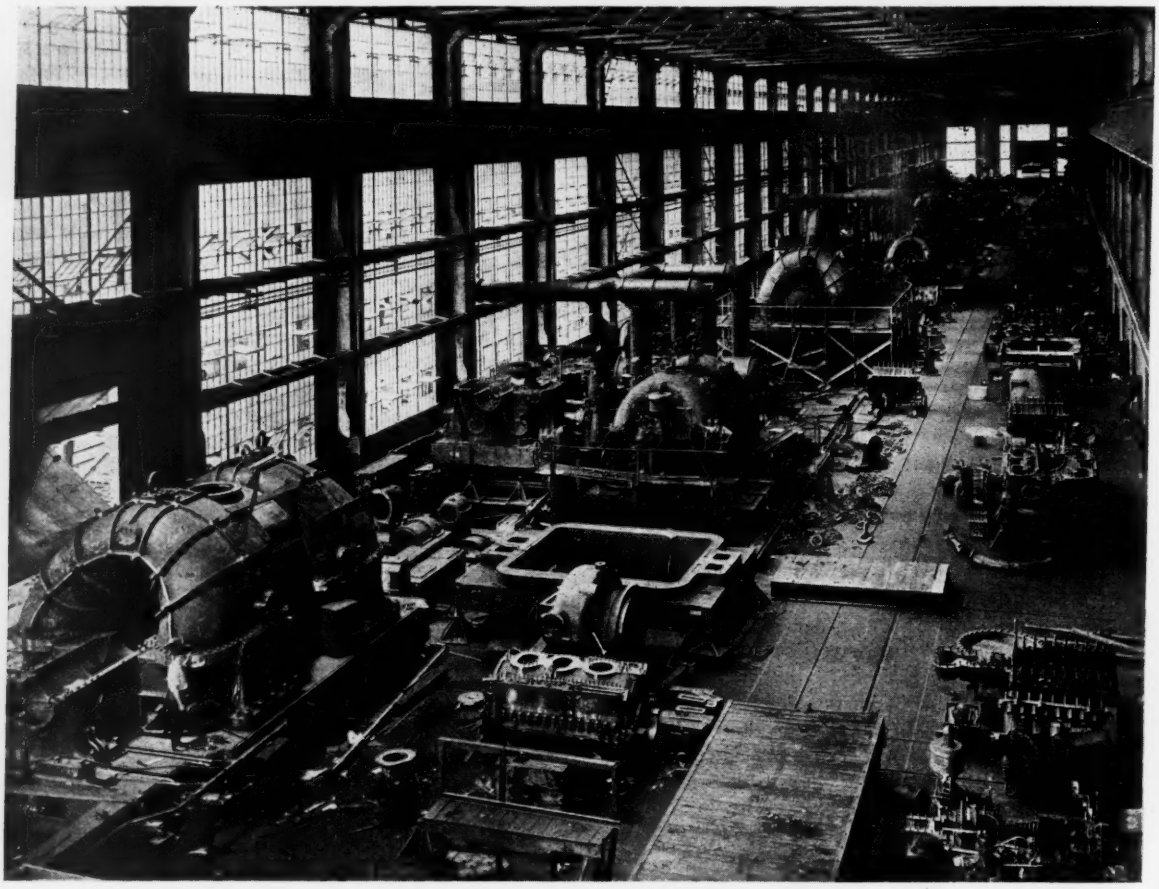
Exposition of Chemical Industries

WHAT promises to be the largest and most interesting chemical industries exposition which has as yet been held will take place in the Eighth Coast Artillery Armory, New York City, during the week of Sept. 12 to 17. As in the past, many of the exhibits will be of great interest to power plant engineers.

A program of technical papers and addresses has been prepared and among these will be an illustrated lecture by R. M. Gordon of the Solvay Process Co. upon the subject, "Modern Boiler House Arrangement and Equipment." John Primrose, of Power Specialty Co., will also give a lecture on "Suggestions for Reducing Heat Losses." Motion pictures of interest to power plant engineers will be shown, the titles being "Conserving Coal and Saving Heat Values by Insulating Steam Pipes and Boilers," "The Cost of Careless Firing," "Getting Most Out of Coal." Among the equipment to be on exhibit are modern means for conditioning air, dust arresters, balances and weights, refrigerating apparatus, fire-fighting equipment, modern means for heating water, various types of filters, water-softening equipment and their uses in industries, pumps and condensers, clay products, automatic controllers for temperature, pressure, time, levels, etc. The fuel situation will be made a feature of the exhibit of Arthur D. Little, Inc., of Cambridge, Mass. As an organization and by individual members of the staff, they have been closely identified with the examination and study of many phases of the problem. In all, some 1900 firms will be represented at this exposition, a large percentage of which have prominent places in the power plant field.

169,000 Kw. of Turbines Tested at One Time

THE CAPACITY of the testing room of the South Philadelphia works of the Westinghouse Electric & Manufacturing Co. was taxed to capacity recently when 169,000 kw. of steam turbine generators were on the test floor at the same time. Nearly 150,000 kw. of this amount was made up of five turbines for some of the largest power companies in the United States.



PHOTOGRAPH SHOWING FIVE LARGE TURBINES ON THE TEST FLOOR

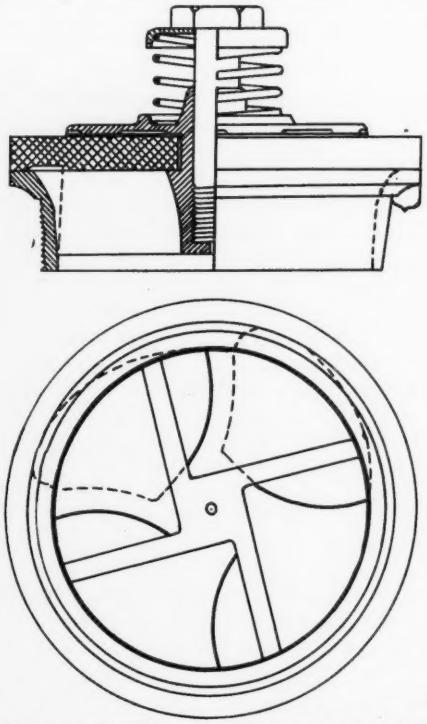
Reading from left to right, these turbines are as follows: 35,000-kw. turbine for the Hellgate Station of the United Electric Light & Power Co. of New York; 25,000-kw. turbine generator for the Gold St. Station of the Brooklyn Edison Co.; 25,000-kw. turbine for the Virginia Power Co., Cabin Creek, Va.; 35,000-kw. turbine for the Calumet Station of the Commonwealth Edison Co., Chicago; 25,000-kw. turbine for the United Electric Light Co., Springfield, Mass.; 10,000-kw. turbine for the American Rolling Mills, Middletown, Ohio.

Inclined Port Hydraulic Pump Valve

A NEW hydraulic pump valve on the market possesses some interesting features, calculated to increase its efficiency and make for prolonged life.

The difficulty with the ordinary valve is that it always seats in the same position with the result that all the wear occurs in a certain restricted area. The result of this continual pounding in one place is that that place wears down and leaves the rest of the valve high. This condition, known as seat imprinting, results in excess leakage and slip.

This valve, manufactured by the Sims Pump Valve Co., and known as the Sims inclined port pump valve, is designed to eliminate this condition. A series of



ELEVATION AND BOTTOM VIEW OF SIMS INCLINED PORT PUMP VALVE

chambers under the valve disc in the valve body deflects the stream of water being delivered through the valve so that the flow, instead of being straight, has a rotary motion. The valve disc has a number of indentations milled on its under face; the column of water on passing through the valve engages these slots and gives the disc a slight rotating motion as it lifts, thus at the end of the discharge the valve seats in a new position. This action causes the disc to wear evenly over its entire surface and its life is consequently increased. The true surface maintained by this motion keeps the contact perfect.

Charles L. Weil

CHARLES L. WEIL, consulting engineer, died at his home in Port Huron July 16. Professor Weil was actively identified with the Diamond Crystal Salt Co. as consulting engineer and in addition maintained an engineering office in Port Huron.

He was born in North Andover, Mass., in 1865. His engineering education was secured in the Massachusetts Institute of Technology, from which he graduated in 1888. After a short period as draftsman with the Worthington Pump Co. he became instructor at Lehigh University, leaving there in 1893 to take charge of the engineering department of Michigan Agricultural College, where he remained for 13 yr. During his connection at M. A. C., Professor Weil designed and installed a complete new power plant for the college which was a model of its kind at the time, and most of which is still giving satisfactory service. He also instituted many important changes and improvements in the engineering department of the college.

From M. A. C. Professor Weil went to Detroit to engage in consulting work, later moving to Port Huron on account of the close connection which he established with the Diamond Crystal Salt Co. at St. Clair, at the same time continuing his consulting practice.

Professor Weil was one of the country's foremost engineers in the evaporation and manufacture of salt. His work was not limited to this phase of engineering, however, as he was active along many other lines, particularly power plant work.

He was a member of the Detroit Engineering Society, Michigan Engineering Society, and the American Society of Mechanical Engineers.

He is survived by Mrs. Weil and two daughters.

Central Indiana Power Plants to Be Consolidated

IF PLANS now being negotiated are worked out, central Indiana will have the principal central station power plants located in the triangle between Kokomo, Indianapolis and Terre Haute, connected into one big system under one management. The plans contemplate the merging of the following companies into one corporation known as the Indiana Electric Corporation: The Merchants Heat & Light Co., Indianapolis; Indiana Railways & Light Co., Kokomo; Wabash Valley Electric Co., Clinton; Putnam Electric Co., Greencastle and Cloverdale; Cayuga Electric Co.; Valparaiso Lighting Co.; Elkhart Gas & Fuel Co. The articles of incorporation have already been filed with the secretary of state at Indianapolis.

Present plans contemplate the building of a big plant on the Wabash River in Vigo County near Terre Haute with high voltage transmission lines to Kokomo and Indianapolis, the triangle being completed by a similar line between Indianapolis and Kokomo. From these lines branches will be taken to distributing stations in every direction and it is contemplated that service will be available to all within the district, particular attention being given to the needs of farmers.

The entire engineering scheme follows closely the suggestions made in a paper by F. L. Ray, published in the March 1, 1921, issue of Power Plant Engineering, the outstanding advantages being the development of a large block of power at the mine mouth where fortunately condensing water is available, the interconnection of existing systems to prevent the possibility of a shutdown in any large section of the territory, and the exten-

sion of service to a greater number of customers in an untouched field.

Credit for bringing the financial interests together in this development is due to Joseph H. Brewer, who has had control of the Merchants Heat & Light Co. of Indianapolis for the past seven years and has been successful in consolidating other systems in Michigan and Wisconsin.

News Notes

YEOMANS BROTHERS Co. of Chicago announces as new representatives: P. E. Fallon, Gazette Bldg., Little Rock, Ark., and Morton McI. Dukehart & Co., McComas & Race Sts., Baltimore, Md.

THE M. J. DOUGHERTY Co., of Philadelphia, announces that it has engaged the Tomlinson Steam Specialty Co., of Cleveland, Detroit and Akron, as representative in the upper half of the state of Ohio and all of Michigan.

E. S. CROSBY, sales and advertising manager for the United States and Cuban Allied Works Engineering Corporation, has resigned to become manager of the eastern district of the Celite Products Co. Mr. Crosby will make his headquarters at 11 Broadway, New York.

U. S. CIVIL SERVICE COMMISSION announces an examination (receipt of applications to close Sept. 20) for assistant mechanical engineer to fill vacancies in the Public Health Service, for duty at various Public Health Service Hospitals within the United States, or in the Bureau of Public Health Service, Washington, D. C., at $2500 to $3000 a year, and vacancies in positions requiring similar qualifications, at these or higher or lower salaries, duties to consist of the supervision of the installation and inspection of plumbing, heating, and electrical equipment in hospitals and of water supply and sewage disposal upon reservations, handling correspondence, reviewing reports, and preparing specifications relating to mechanical equipment in general. Applicants must have reached their twenty-fifth but not their fiftieth birthday on the date of the examination. These age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating examination title.

Catalog Notes

LINK-BELT Co., of Chicago, has just issued a new Steel Chain Data Book No. 475, which presents completely the heavier rugged steel chains used for power transmission, also including elevating and conveying chains.

Copies can be secured by any of our readers interested in this subject by addressing the Link-Belt Co.

We quote from the foreword of this book: "Malleable iron sprocket chains manufactured by the Link-Belt Co. have served their field for more than 40 yr., but the demand for chains that will run at higher speeds and under greater loads has been so insistent that a line of steel chains has been developed which is completely presented in this booklet for the first time.

"The line ranges from the rugged slow-speed classes to the machine finished high speed chains, accurate as to pitch, ample as to joint bearing surface, with a joint construction permitting free lubrication, and material specially selected and treated to provide strength and toughness in the side bars, and to resist wear in the joints."

TRICO renewable cartridge fuses are described in a folder from Trico Fuse Mfg. Co., of Milwaukee, Wis.

A NEW illustrated catalog on the subject of the Bigelow fire-tube boiler has been received from The Bigelow Co., New Haven, Conn.

SAFEGUARDING VERTICAL TRANSPORTATION is the title of a pamphlet from Utility Safety Appliance Corporation, New York, discussing Schlesinger's safety interlock system.

OPERATING HISTORY of Westinghouse Turbine Units of 30,000 Kw. and Higher, is the title of Reprint No. 91, which gives the operating history of some Westinghouse steam turbine units. This series covers the record of the performances of these turbines, of any trouble they have had, and some interesting features connected with their operation. There are eight articles, embracing 11 of these large units. They include turbines installed at the Interboro Rapid Transit Co., New York; the Commonwealth Edison Co., of Chicago; the Edison Electric Illuminating Co., of Brooklyn, N. Y.; the Brooklyn Rapid Transit Co.; the Duquesne Light Co., of Pittsburgh; and the Narragansett Electric Light Co., of Providence, R. I. There is much interesting information to be gained from a careful study of this pamphlet.

SUPPLEMENTING the thorough description of synchronous motors given in its Bulletin No. 41,309, the General Electric Co. has issued Bulletin No. 48,032, entitled "Synchronous Motor Control Apparatus and Exciters." In this bulletin, the description of synchronous motor control apparatus is divided into four sections—exciters, compensators, panels and rheostats.

There are four general types of exciters. These are direct-connected exciters, DD-O; direct-connected exciters, DS-2; belted exciters, and exciter motor-generators. In general, the bulletin says, direct-connected exciters are used with high speed motors of over 500 or 600 r.p.m. For the slower speed motors, it is cheaper as a rule to use belted exciters. For very large machines or where it is desired to excite several machines from one exciter, motor-generators are recommended.

The bulletin describes, with illustrations, the five standard types of direct-connected DD-O exciters and the two types of belted exciters, as well as the other types mentioned. The four general types of compensators for use with synchronous motors are covered in similar detail, as is the case with the switchboard panel equipment and the rheostats.

Diagrams of connections, and tables of compensator dimensions and of compensators for use with different motor types are included. In dealing with the belted exciter, the bulletin also gives formulas for the relation between pulley ratio, distance between centers and the diameter of the smaller pulleys, for any given arc of contact.